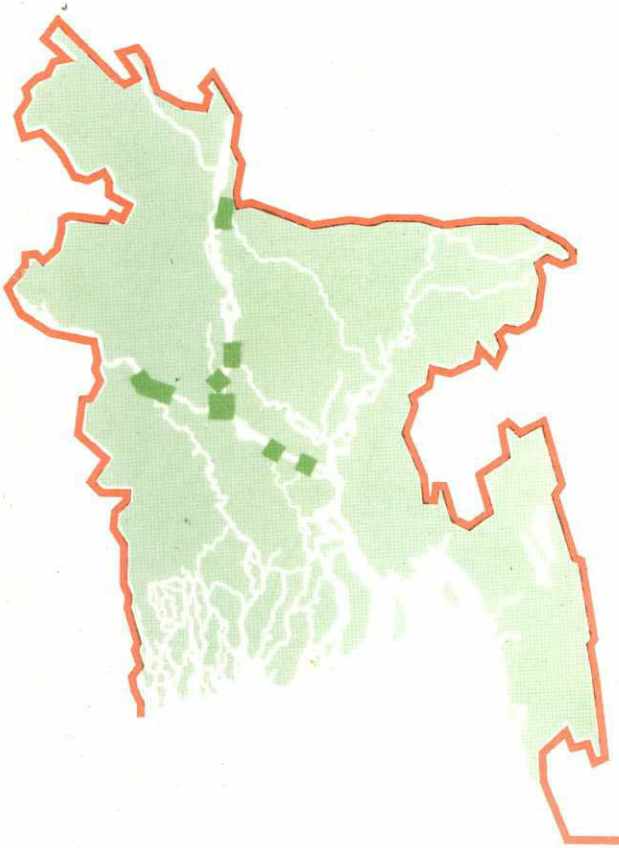
GOVERNMENT OF BANGLADESH
FLOOD PLAN COORDINATION ORGANIZATION

FAP 24 RIVER SURVEY PROJECT

1° Interim Report
Volume I : Main Report



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Project ALA/90/04 — Commission of the European Communities

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1° Interim Report

Volume I : Main Report

February 18, 1993

FAP 24 **RIVER SURVEY PROJECT**

Flood Plan Coordination Organization

DELFT-DHI **Commission of the European Communities**

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February 18, 1993

The Chief Engineer
Flood Plan Coordination Organization (FPCO)
7 Green Road, Dhaka.

Subject : **Interim Report**

Dear Sir.

With pleasure we submit herewith 50 copies of our Interim Report. The report consists of three Volumes :

Volume	1	:	Main report
Volume	2	:	Annexures on survey work
Volume	3	:	Annexure on studies, etc.

Please note that the report contains a proposal on workplan revisions (main report Chapter 8 and Annexure 9). In accordance with the ToR, sub-section 4.4.2 a detailed workplan for the second half of phase 1 is presented for your kind approval.

We are looking forward to receiving your comments.

Yours sincerely

Pieter van Groen
Team Leader

CONTENTS OF THE INTERIM REPORT

MAIN REPORT
(Volume I)

Contents main report

1. Introduction

1.1 River Survey Project FAP 24

The River Survey Project (FAP 24) started in June 1992 as one of the supporting activities of the Flood Action Plan.

The main components of the project are:

- o Surveys
- o Studies
- o Training

Surveys

The objective of the survey is to collect reliable all season hydrological and morphological data at key locations of the country's main river systems. These types of surveys are routinely done so far by Bangladeshi organizations applying traditional methods and equipments which have shown their limitations in the high flow ranges. However, the hydro-morphological data of these ranges are crucial for the design of flood control works as embankments, river training and bank protection. Therefore the River Survey Project will emphasize the data collection during the monsoon season, introducing improved or new technology where possible and appropriate.

Studies

Special studies will be undertaken aiming at a further understanding of the behaviour of the main river system in Bangladesh. Starting points for these studies are obviously the existing studies done and the data already collected, especially within the FAP context. Besides that, use will be made of the fresh data collected by the River Survey Project (sometimes purposely measured during supplementary surveys for a study topic).

Training

On-the-job training will be provided to, among others, BWDB staff both in the fields of surveys and studies. The objective of the training is to upgrade the capability so that, after the River Survey Project, the relevant staff can continue the data-collection and the study programme.

The project period is divided into Phase 1, taking about one year in which the survey techniques and the study and training programmes will be selected and Phase 2, the subsequent 3 years, in which the surveys are done and the programmes are implemented.

1.2 Interim Report

Half a year after the start of the project the first Interim Report was planned summarizing the results of the surveys and studies completed and presenting a detailed workplan (FAP 24, 20 October 1992, ToR, Section 4.4) for the other half of Phase 1.

The Interim Report was consequently planned to be drafted by the end of November 1992 (FAP 24, 20 October 1992, Figure 3.2). The main issues to be covered by the report are the test measurements, initially scheduled for September, but, due to administrative problems, delayed and finally executed at the end of October 1992. Therefore, it was agreed to postpone the reporting to January 1993.

In January it became clear that a considerable revision of the workplan was unavoidable and that an outline of the new workplan had to be inserted in the first Interim Report. Therefore, this report was submitted in February 1993.

The Interim Report comes in three volumes. This Main Report (Volume I) is a kind of executive summary presenting the main results of the test measurements done in October and December 1992 and the main results of the studies. Volume II and III contain the annexures to the Main Report. In Volume II survey topics and in Volume III the study topics are emphasized.

2. Review of activities

The main activities of the River Survey Project are given in the following schedule:

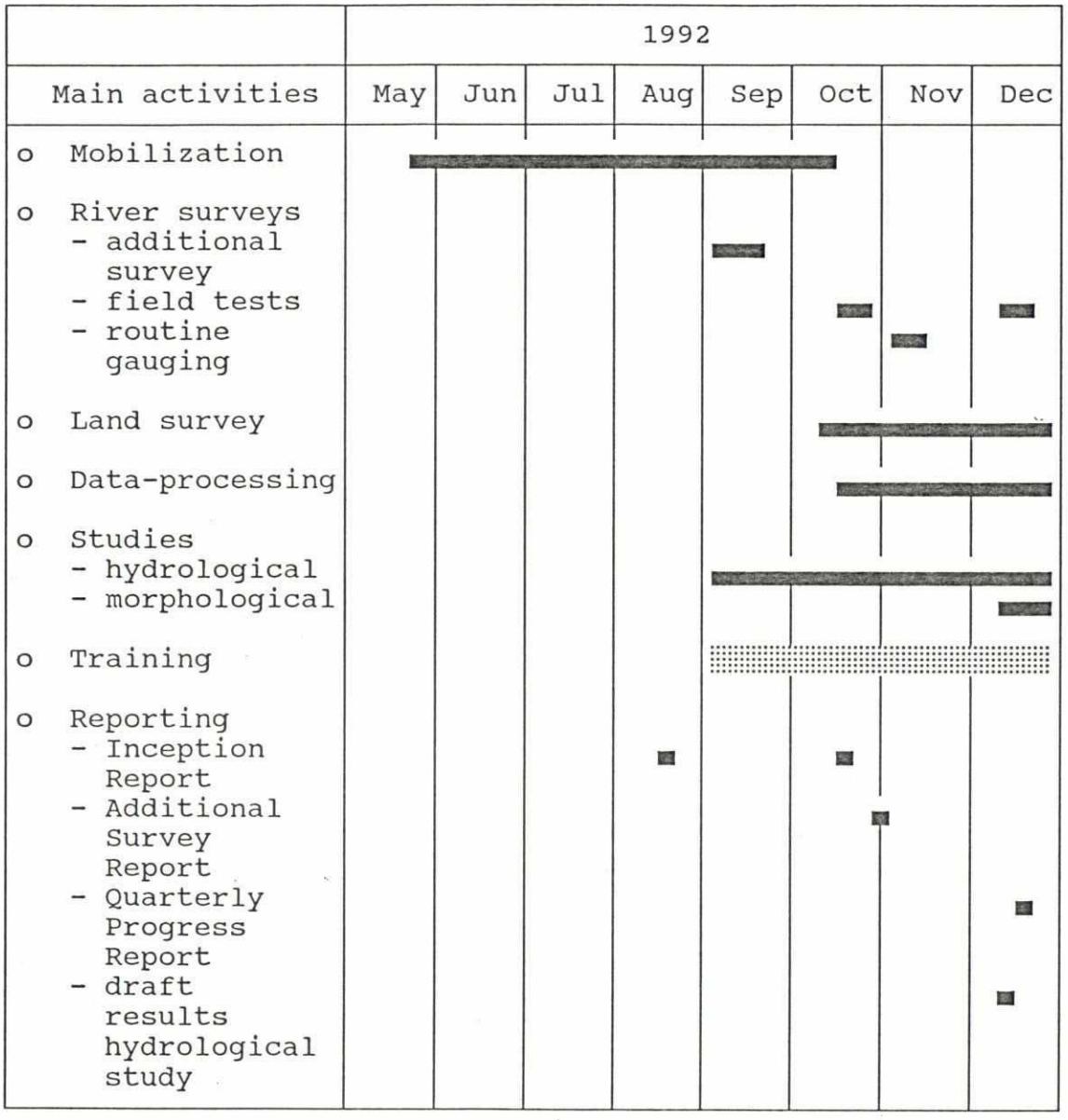


Figure 2.1 Main activities

2.1 Mobilization

Mobilization started just after the award of the contract. In Europe the main mobilization activities comprised the procurement of equipment including instruments and vessels. In Bangladesh the former MPO office (House No. 96, Road No. 23, Banani, Dhaka) was rented to be used as workshop, data-processing office, general office and staff residence. Also a field office in Gaibandha was put into operation. In the Netherlands a coastal patrol vessel was modified for survey purposes and in Singapore a new catamaran-type of boat was constructed. The vessels were transported on board of cargo vessels to Chittagong and sailed on their own keel to Narayanganj, where the survey equipment was installed at a yard. The end of the installation marked the end of the mobilization for Phase 1.

Some mobilization milestones are:

o	Award of Contract	May 22, 1992
o	Inception of Phase 1	June 9, 1992
o	Arrival of equipment in Bangladesh	August 4, 1992
o	Arrival survey vessel (DHA)	August 22, 1992
o	Release of equipment	September 7, 1992
o	Release of vessels	September 22, 1992
o	End of installation	October 15, 1992

For more details reference is made to the Revised Inception Report (FAP 24, 20 October 1992).

2.2 River Surveys

The river surveys executed in 1992 are:

- o Additional survey done in September with rented equipment and vessels (Anwesha with two tender boats) on the Jamuna near Bahadurabad
- o Test measurements in October near Bahadurabad
- o Routine gaugings in November near Bahadurabad
- o Additional test measurements in December on the Lower Meghna

The results of the additional survey have been elaborated in "Additional Survey September 1992" (FAP 24, 31 October 1992). Probably the most important conclusions of this report are:

(quote)
6) The significant difference between the presently measured discharge and the discharge according to BWDB rating curve of 1989 could not be explained.
7) It is observed that the flow directions vary considerably within one cross-

section. Therefore detailed and accurate measurements of the flow direction are prerequisite to avoid considerable errors.
(unquote)

These observations asked for further analysis and therefore "Analysis of the Anwesha Survey Results" was made a study topic in the hydrological study programme (ref. Chapter 5).

In this Main Report the result of both tests measurements (of October and December) are summarized in Chapter 3. For more information reference is made to Volume II.

2.3 Land survey

The land survey started with levelling between bench-marks and staff gauges at both sides of the Jamuna near Fulcharighat and Bahadurabad.

2.4 Data-processing

By mid November the installation of the data-processing office was completed in terms of hardware, system software, standard DELFT-DHI and general software. Special software for FAP 24 was written and tested by the end of the year. Further quality checking and reporting demands will lead gradually to the final methods and formats for processing and reporting. The sediment laboratory started in November and executed the following type of analysis:

- Concentration of suspended sediments
- Particle size, dry sieving
- Particle size, settling tube

For results reference is made to Volume II.

2.5 Studies

Two types of studies are distinguished:

- The hydrological study
- The morphological study

Both types of studies started with collecting data and reports. The hydrological study started early September and the morphological study started by the end of the year.

The established study programmes and the main results have been summarized

in Chapter 5 and 6 of this volume. For more details reference is made to Volume III.

2.6 Training

Training, given by expatriate staff, in 1992 comprise:

- Ship handling, maintenance and manoeuvering
- Data-processing
- Sediment analysis
- Surveying

As defined in the ToR (FAP 24, 20 October 1992, Subsection 4.2.c and 4.3.c) the training should be given to:

- BWDB staff
- BIWTA staff (where applicable)
- Staff of associated local consultants and contractors

Consequently, training is given both as an internal training (for FAP 24 staff, including associated staff) and as an external training (BWDB, BIWTA, etc.). For the last three items staff from other organizations were invited via FPCO. The survey work was attended by BWDB staff. For further information on training reference is made to Chapter 7 and Volume III.

2.7 Reporting

The Inception Report of August 1992 was revised in October. Comments on the Revised Inception Report (FAP 24, 20 October 1992) have been received from various sources and are presented and discussed in Volume III, Annexure 5.

On the Additional Survey Report (FAP 24, 31 October 1992) no comments have been received so far (ref. Section 2.2).

The first Quarterly Progress Report (FAP 24, 19 December 1992) has been published in draft. The report, mainly a supporting document for the external invoicing, covers the period of September to November 1992.

The first preliminary results of the hydrological study were assessed to be so important that an intermediate reporting was undertaken in December. The results are summarized in Chapter 5 and elaborated in Volume III, Annexure 6.

3. Summary of test measurements

In general test measurements or test gaugings on the river comprise:

- o Performance tests (to check equipment)
- o Trials (to check operational procedures)
- o Optimization tests (to optimize measuring methods)
- o Overall tests (to determine the appropriate technique)

The overall tests are a verification of the total result of the other more detailed tests (ref. Volume II).

Because of the late project start, the first measurements in the River Survey Project were scheduled to be the test gauging foreseen in the BoQ. However, the extremely low monsoon discharges in October 1992 impeded the realization of a complete test gauging programme.

As described further, additional tests were performed in December 1992 on the Lower Meghna aiming at assessing the performance of equipment in higher velocities and sediment concentrations.

Final testing is envisaged in August 1993 in high flow conditions. The following sections summarizes the tests of October and December.

3.1 Test gauging in October 1992

3.1.1 Objectives

The objectives of the test measurements scheduled for October 1992 at the Bahadurabad site were to:

- o Make an objective comparison between the standard testing of various types of equipment and the new, modern technology, especially in view of their use in peak flow conditions in terms of performance, reliability and accuracy
- o Optimizing the gauging procedures with respect to measurement sampling density and frequency

Prior to execution of any test measurements a site reconnaissance, for selection of a suitable measurement cross-section, as well as an inter-calibration between the individual current meters and the ADCP was carried out.

The testing programme has been described in details in the Inception Report (FAP 24, 20 October 1992, Appendix G) and a summary is provided in the following.

3.1.2 Testing Programme

Upon arrival at the site it was realized that the water-level had fallen drastically since peak flow conditions and that the situation continued with approximately 8 - 10 cm reduction per day. Based on this observation it was agreed that execution of the test gauging programme as originally planned would be irrelevant and that a reduced programme should be implemented.

In principle the testing programme included comparison of three different measurements methodologies for discharge gauging as well as some trials with suspended sediment transport gauging by point- and integrated-sampling technique respectively.

Standard Method

This is the method for discharge gauging or test gauging by velocity-area method with current meters.

For manual discharge gauging the selected river cross-section is classified into main and smaller channels as well as shallows (ref. Figure 3.1):

- Main channels are 500 m to 2 km wide, (geometric width) maximum depths ranging from 5 m to 25 m, exceptionally amounting to 30 m or even more at intensive scouring places
- Minor channels are here defined as having widths ranging from 100 m to 500 m and maximum depths between 3 m to 10 m
- Bars and shallows are those zones without well defined minor channels as described before, but where depths exceed 3 m (as related to the water-level at the moment of the gauging)

The test gauging procedure shall comply with the following requirements:

- In main channels
  - Maximum distance between verticals (stations) 100 m
  - Six-point method for each vertical
  - 300 seconds integration time for each velocity sampling (with record of sampling at each 50 seconds interval)

o In smaller channels

- Four verticals (stations)
- Three-point method for each vertical
- 100 seconds integration time for each velocity sampling (with record of sampling at 50 seconds)

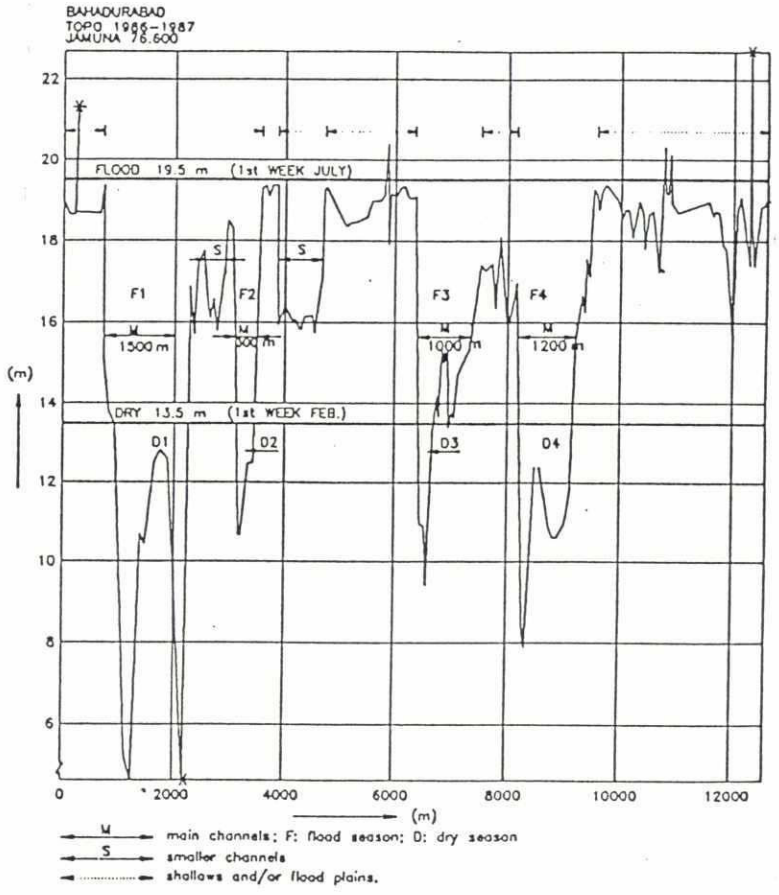


Figure 3.1 Typical Cross-profile at Bahadurabad

Alternative Methods (Recommended Method)

Two alternative methods have been included in our proposal for testing i.e.:

o Moving boat using EMF
o Moving boat using EMF and ADCP simultaneously

In order to increase the accuracy of the gauging and to obtain the optimum basis for the comparison between the standard and the recommended method it was decided to increase the number of discharge measurements using EMF and ADCP simultaneously. Complete crossings were made before and after each series of manual profiling.

Sediment Transport Gauging

Suspended sediment test gauging was carried out simultaneously with the flow test gauging using the velocity-area method as follows:

o Point sampling

- number of samples in water depths larger than 3 m was:
  close to surface as possible
  0.2 x D
  0.4 x D
  0.6 x D
  0.8 x D
  close to bottom as possible
- number of samples for depths less than 3 m was:
  0.2 x D
  0.6 x D
  0.8 x D

o Integrated sampling

In some of the verticals a depth-integrated sample of suspended sediments was taken for comparison. This exercise will be continued.

o Turbidity Measurements

Suspended sediment sampling was supplemented with turbidity measurements for comparison.

In order to obtain more experience and a more comprehensive database, the measurements will be continued after the testing programme.

The prospect is to replace some of the relative time consuming suspended sediment sampling with the more efficient turbidity measurements.

o ADCP suspended sediment measurements

The manual suspended sediment sampling and turbidity profiling is also supplemented with back-scatter intensity measurements during the ADCP crossings.

The measurements give the relative variation of suspended sediment concentrations in the cross-section and may be used for planning of locations for suspended sediment sampling, thus allowing to optimize the gauging effort. The combined information on suspended sediment and flow distribution supports further analysis of sediment transport and related morphological processes in the river.

o Laboratory analysis of sediments

The following analysis have been carried out at the project laboratory in Dhaka:

- suspended sediment concentration, by Millipore micro-filtering
- grain size distribution of suspended sediments, by Andreasen settling tube test
- grain size distribution of coarse river-bed sediment, by wet sieving
- grain size distribution of fine river-bed sediments, by hydrometer testing

o Bed load transport measurements

Trials were made with the side scan sonar to record the general river-bed configuration, showing sand dune patterns with lengths and orientation.

It was also planned to measure the bed load transport by frequent monitoring of sand dune movements by echo-sounding in a relative dense grid of survey lines. Upon arrival at the site it turned out that the river-bed in the measurement cross-sections was smooth and that location of areas with well developed sand dune movements would be difficult to find in the existing river conditions with the water-level falling drastically. It was therefore decided to postpone these trials and maybe carry them out at another location.

Bed load transport was measured using the Helley-Smith trap-type sampler.

3.1.3 Measurement Procedures

Selection of measurement cross-sections

Upon arrival at the site a general reconnaissance was carried out on land for location of suitable fix points for positioning as well as on the river itself to search for areas with reasonable smooth bottom configuration and flow conditions with no eddies or flow from secondary channels.

As a result supplementary fix points had to be constructed close to the river bank on both side of the river - south of Fulchari and Bahadurabad - respectively and their levels measured relative to PWD datum.

At Bahadurabad the Jamuna River follows two main streams separated by a vast, inhabited char (ref. Figure 3.2). This means that a full discharge gauging involves measurements in two separate cross-sections. Suitable discharge measurement cross-sections were found also south of Fulchari and Bahadurabad respectively.

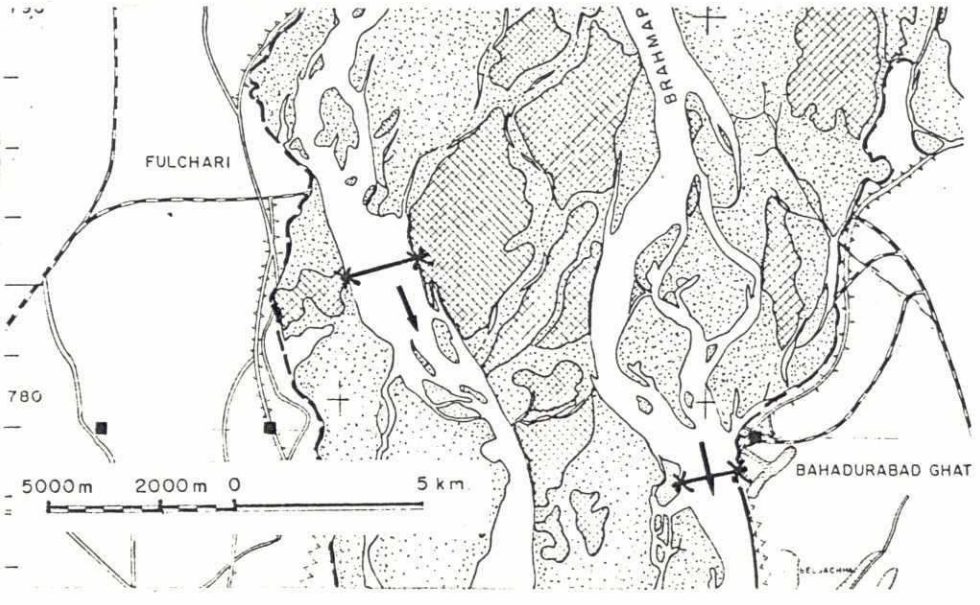


Figure 3.2 Indicative location of measurement cross-section
The individual cross-profiles are illustrated on Figure 3.1

Positioning

During navigation and positioning on the rivers a differential satellite positioning systems (DGPS) is planned to be used. Operating the system requires transmission of distance correction values by a UHF radio link between a master station installed in a known fix point on land and the survey vessels.

At the time of initiating the testing programme necessary frequency licenses for operating the radio link were not released by the concerned authorities and it was decided to carry out the programme using GPS only (instead of differential GPS (DGPS)) and thereby accept a lower accuracy for horizontal positioning during measurements. The main impact of this lack of accurate positioning is:

- Inaccurate determination of the locations on the river for individual profiling and thereby discharge calculations by the velocity area method

- Inaccuracies in the horizontal scale of the echo-sounder cross profile

- Inaccuracies in the EMF measurements which are based on the DGPS accuracy. Consequently, the overall inaccuracy of the discharge calculation using EMF

It does not influence the inter-calibration of instruments and the ADCP discharge gauging is based on bottom tracking and is as such not influenced by the inaccurate positioning.

The problems related to the implementation of the DGPS system may be summarized as follows :

Up to present (mid February) the necessary frequency license for operating the radio link has been obtained but the permission to actually install the reference antenna in the measurement area in Fulchari is still pending.

The operation of DGPS calls for a reference point in form of a bench-mark with known co-ordinates based on the WGS 84 ellipsoid.

The consultant has not been able to obtain any reliable co-ordinates for the bench-marks established by FAP 18 in the Bahadurabad area or elsewhere in Bangladesh.

Investigations and contacts with other FAP projects indicate that Survey of Bangladesh (SoB) intends to release co-ordinates on the bench-marks in the near future.

However, it is also indicated that those co-ordinates will be given based on an, at present unknown, Everest ellipsoid.

As GPS always measures with respect to the WGS 84 ellipsoid, the co-ordinates released by SoB must be converted to WGS 84 co-ordinates by means of some co-ordinate transfer calculations - a "datum shift".

The consultants are not able to carry out this datum shift, due to lack of information regarding the Everest ellipsoid to be used by SoB.

This means that the consultants cannot establish an accurate positioning annotation of the survey data in the applicable system until this problem is solved.

It was understood at the proposal stage, that FAP 18 on behalf of the SoB was establishing GPS bench-marks in Bangladesh and that the River Survey Project would be provided with accurate co-ordinates based on the WGS 84 ellipsoid in order to operate their proposed DGPS system.

Bench-marks

The following fix points have been applied for the measurements at Bahadurabad cross-section.

Location	Bench-mark	BTM co-ordinates		Elevation (PWD datum)
		x	y	
Kamarjani north of Manos	FMBM 7603 FMBM 7604			20.57 m 22.60 m
Bahadurabad	GPS 764 FMBM 5244	2778134.75 m	471089.58 m	20.31 m 19.86 m
Gaibandha	FMBM 7507 FMBM 7601 GPS 7	2800728.61 m	454149.20 m	21.62 m 20.80 m 21.97 m
Fulcharighat	FMBM 7305 FMBM 7401 GPS 765	2782540.83 m	452530.93 m	18.54 m 19.17 m 20.36 m

Notes: All values are preliminary.

Conversion to Mean Sea Level datum can be made by subtracting 0.4599 m from the PWD datum levels indicated in the table.

Source: BIWTA and Finnmap Oy.

Table 3.1 Bench-marks for Bahadurabad cross-section

Water-level measurements

Installation of automatic water-level recorders is awaiting a clarification of technical alternatives in form of an acoustic or a pressure cell instrument. The final location also has to be decided awaiting some further reconnaissance on the site.

Until then manual staff readings related to the newly constructed levelling points are carried out on both sides of the river.

Requirements to possible water-level slope measurements also have to be determined.

Discharge measurements by ADCP and EMF (moving boat method)

Conventional discharge measurements by a series of manual profiling across the river (velocity-area method) can be accurate if properly organized and performed. However, the method is time consuming and resource demanding in terms of manpower and boats. This leads in general to a comprise between spatial density and time (duration of sampling and total measurements). Measurements lasting days may become inaccurate when flow conditions change markedly during the measurements, which quite often may be the case in the rivers of Bangladesh.

In order to overcome these problems the Acoustic Doppler Current Profiler (ADCP) concept was introduced and in combination with the EMF installed in a fixed level of 0.5 m - 1.0 m in the front of the vessel this instrument configuration constitutes the consultant's alternative method for "instantaneous" discharge gauging in the main channels.

"Instantaneous" means that the measuring time equals the travel time of the vessel crossing the river at a survey speed of 3 - 5 knots. The optimum survey speed of a vessel with ADCP in a possibly pulsating flow needs further clarification.

In summary the Acoustic Doppler Current Profiler (ADCP) methodology in the main channels is considered to provide the most accurate discharge measurement, as well as the highest data coverage within the shortest measuring period.

The principle instrument installation is illustrated in Figure 3.3 and a typical example of record, illustrating the detailed current distribution in a cross-section, is shown in Figure 3.4 and 3.5.

Actual measurements are carried out by crossing the rivers from one bank and during sailing the system will record high resolution vertical profiles for every 5 - 10 m along the transect and continuously present the profiles and calculate the discharge by integrating the velocity normal to the path taken by the survey vessel.

The ADCP can't measure the velocity close to the river-bed, due to transducer side loops, nor the velocity close to and above the immersion depth of the transducer. Close to the river-bed the velocity profile is extrapolated using hydraulic calibration and extrapolation at the surface is based on the EMF measurements. Further refinement of the off-line

computation is envisaged based on additional measurements and analysis of the lower current profile

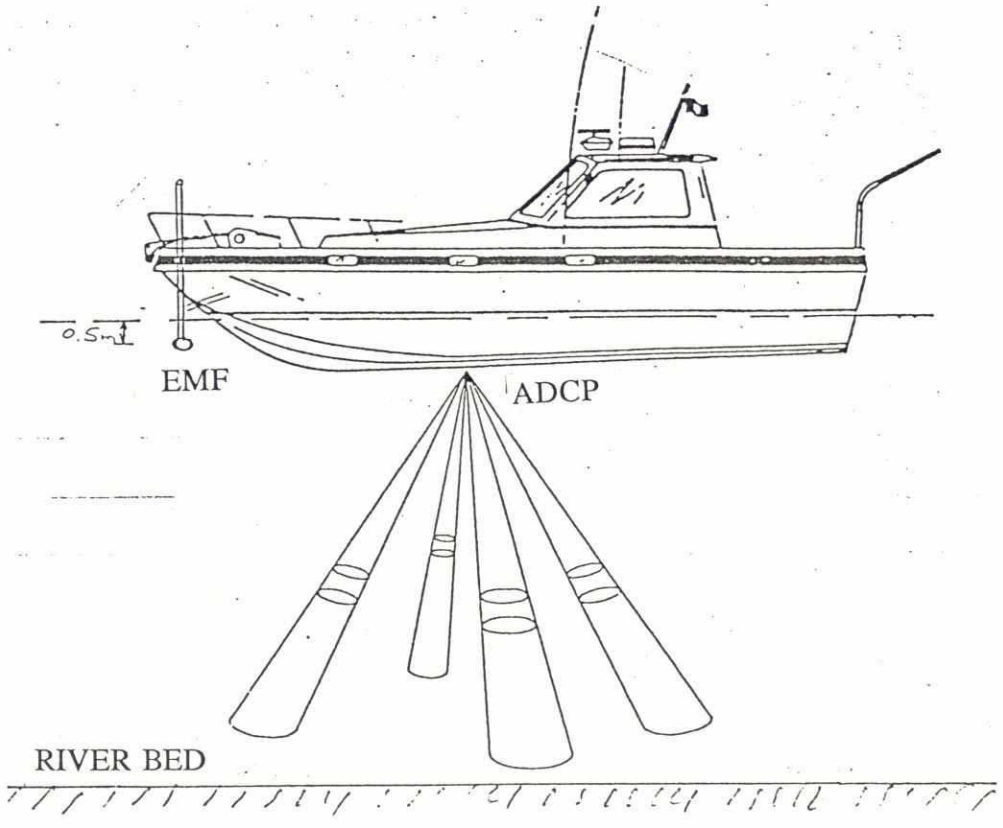


Figure 3.3 Principle sketch of instrument installation for the recommended method with EMF and ADCP

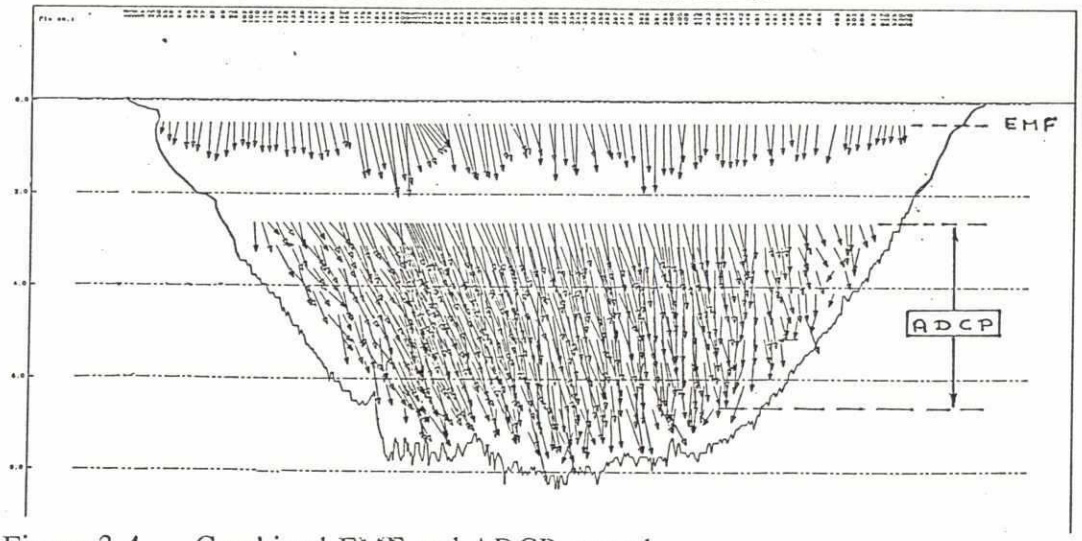


Figure 3.4 Combined EMF and ADCP record

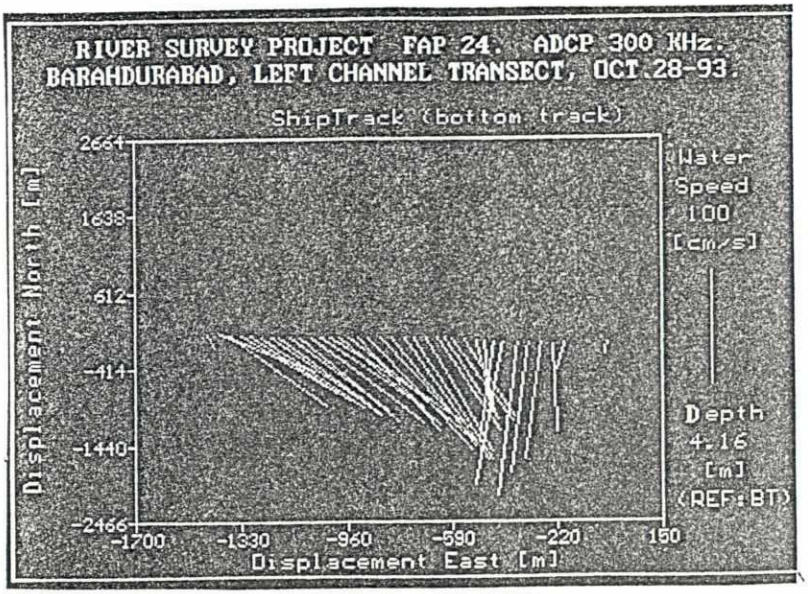


Figure 3.5 Example on horizontal current distribution at a certain predefined level

Velocity and suspended sediment measurement by manual profiling (velocity-area method)

Measurements of suspended sediment concentrations is an integral part of the overall field investigation programme and is very time consuming and resource demanding.

The current velocity and suspended sediment profiling is carried out in a simultaneous operation using the combined sediment suction and velocity measurement device as shown in Figure 3.6.

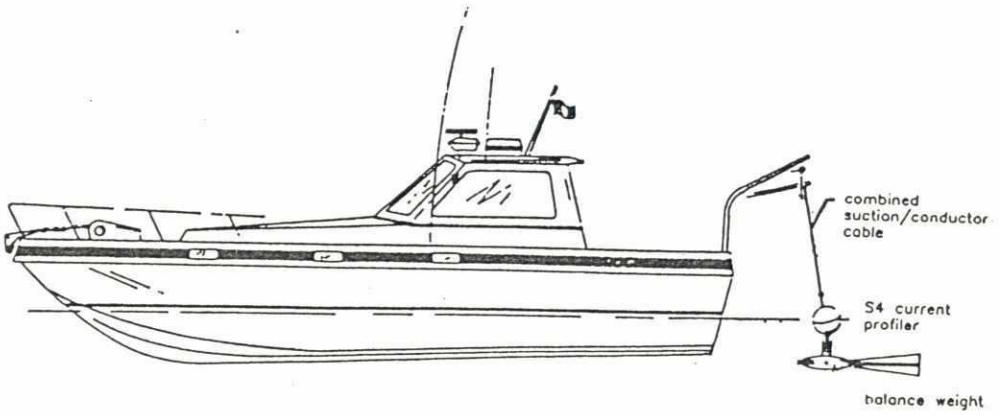


Figure 3.6 Principle sketch of equipment installation for combined current profiling and suspended sediment sampling

The measuring depth is recorded by a pressure cell included in the current meter and is monitored continuously during operation.

During the test gauging phase and generally in the beginning of the project, the distances between profiles in the river cross-section as well as the numbers of measurements in each profile are determined by the contract specifications.

Later on the sampling operation shall be optimized in terms of coverage densities and selection of locations for profiling will be based on evaluation of recorded ADCP cross-profiles including the back-scatters density record showing the relative variation of suspended sediment concentrations in the water.

During sampling the boat is normally anchored in the selected position. In situations where anchoring becomes difficult - not to say impossible - dynamic positioning will be established relative to a light marking buoy which is deployed temporarily during the measurements or by using the DGPS based navigation system on board. In how far dynamic positioning can be applied during near river-bed measurements needs further to be sorted out.

Alternatively, as a contingency procedure during extreme flow conditions, it can be required to allow for a drifting of the boat during the sampling, in order to reduce the current force on the submerged part of the sampling

device, and also in order to reduce the ratio between the current velocity and the nozzle intake velocity. If so, the boat will be relocated in between each sampling. Near river-bed measurements cannot be done in this case.

Up to now a sediment sampling integration time of 3 minutes (e.g. 6 x 50 seconds) has been employed. Samples have been collected in 0.5 l bottles. Supplementary 10 l samples have been collected at the lowest suction level for Andreasen settling tube determination of grain-size distribution.

During suspended sediment sampling turbidity measurements are carried out simultaneously and in the same points.

Mapping of river-bed configuration for detection of sand dune patterns.

A side scan sonar system has been installed on board on a temporary basis until the final need has been clarified.

The system consists of a pair of transducers mounted in a fish being towed behind the survey vessel during operation. The recorder is installed in the data-processing room on board. Side scan sonar survey is carried out in longitudinal lines covering the areas of interest for sand dune tracking. The records show details of the general river-bed configuration including sand dune lengths and indicative heights.

A typical example of record is shown in Figure 3.7 below.

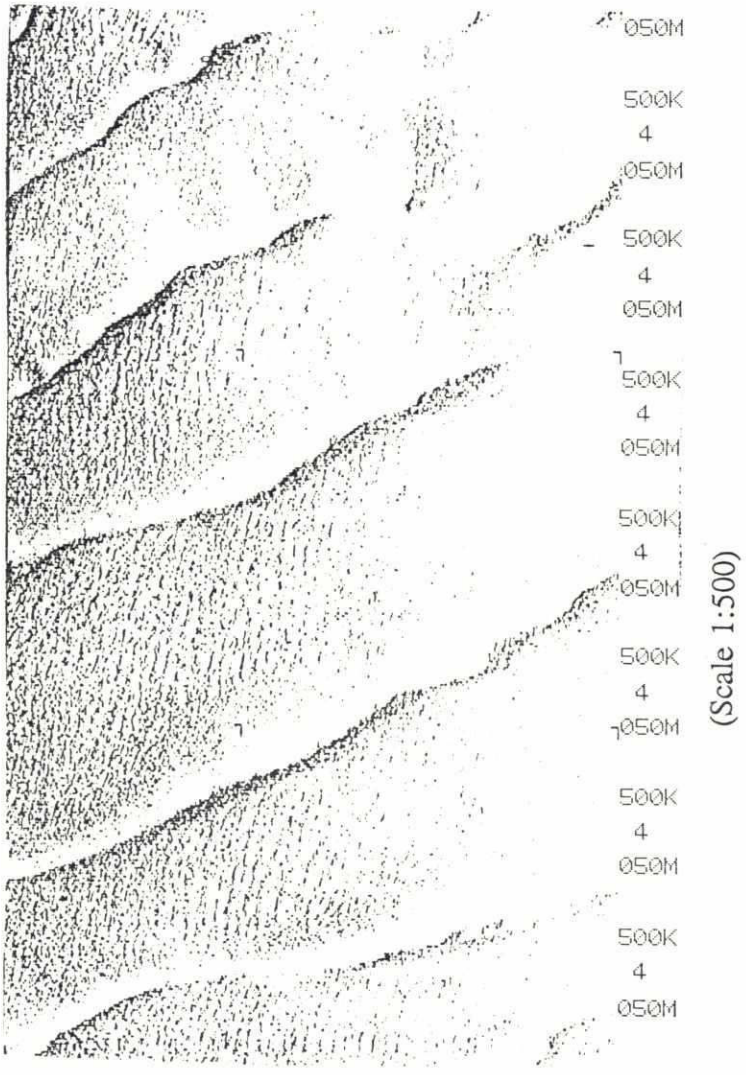


Figure 3.7 Side scan sonar record from Bahadurabad

Bed load transport measurements

During the test gauging bed load transport measurements have been carried out using the Helley-Smith trap sampler only. The samples were taken during the suspended sediment- and current-profiling, mentioned above. 2 minutes duration samples were collected 3 times at each location.

Due to the fact that flow conditions were low compared to normal peak flood level bed load transport measurements by monitoring of sand dune movements during intensive bathymetric survey campaigns of 1 - 2 days duration have been postponed into the coming flood season. Additional tests with some alternative, still to be defined, instruments should be foreseen.

Bed material sampling

This measurement discipline has to be further investigated and clarified. Up to now only a few grab samples have been collected from the river-bed. In addition to this a few samples have been taken from some shoals becoming dry during the falling water-level.

3.1.4 Measurement Results

General

All valid measurement data is quantitatively listed in Volume II, Annexure 2. A few key results are presented in the following. Conclusions on instrument performance during the test gauging is described in Chapter 4.

Water-levels

As mentioned earlier it was found that the water-level had fallen drastically since peak flow conditions and that the situation continued with approximately 8 - 10 cm reduction per day. Some key values of water-level recordings are presented in Figure 3.8 below.

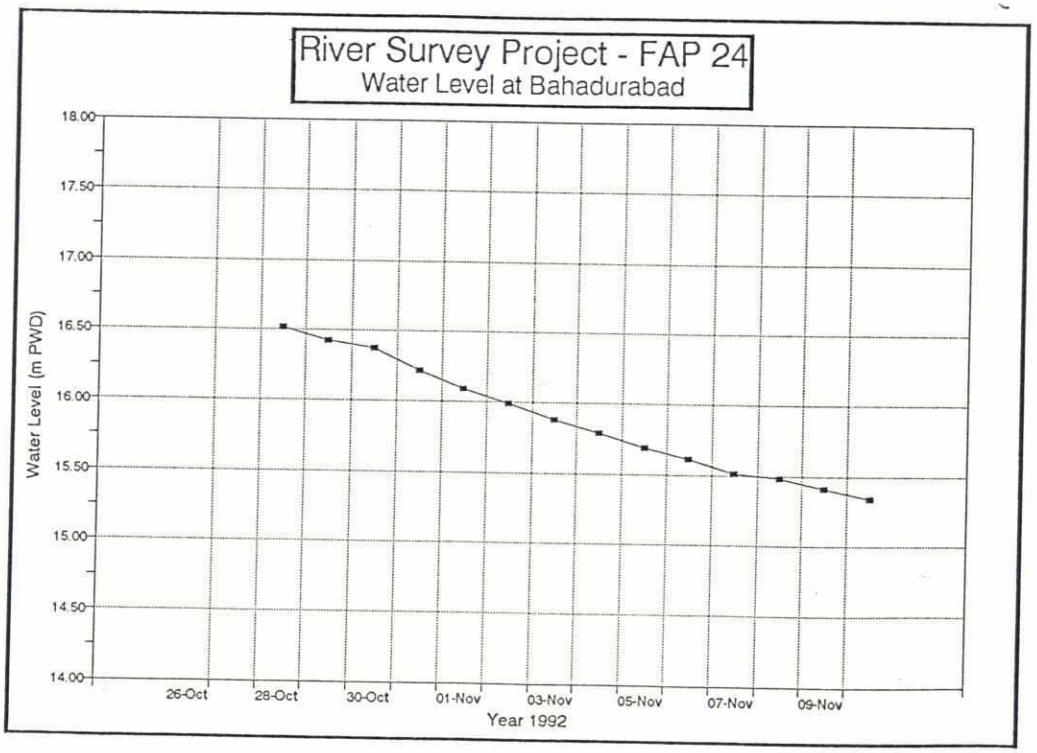


Figure 3.8 Water-level recordings at Bahadurabad

Discharge measurements by ADCP and EMF (moving boat method)

During the test gauging in October 1992 in the right river channel and the following flood season routine gauging covering both river channels several discharge cross-sections (trans-sects) were carried out using the combined instrument configuration of ADCP and EMF. The results of October are listed as follows:

Date	Location	Discharge in m^3/s
26/10/92	Right Channel	7,353
	Right Channel	7,741
27/10/92	Right Channel	7,426
	Right Channel	7,000
29/10/92	Left Channel	11,744
	Left Channel	11,778
	Left Channel	11,859
30/10/92	Left Channel	10,768
	Left Channel	11,084
	Left Channel	11,413
31/10/92	Left Channel	10,789
	Left Channel	10,218

Table 3.2 Discharge measurements by ADCP and EMF (EMF without differential GPS causing quite some scatter in the surface discharge component).

The discharge values reflect the falling water-levels and also illustrate the level of inaccuracy introduced by the longer measurement periods required to cover the cross-sections by manual profiling - say 2 - 3 days.

These differences are further dealt with in Volume II.

Velocity and suspended sediment measurements by manual profiling (velocity-area method)

o Discharge

During the measurement campaign three cross-sections were carried out by manual profiling as follows:

Date	Location	No. of verticals in each cross-section	Discharge in m^3/s
26-27/10/1992	Right Channel	15 *	7,700
29-31/10/1992	Left Channel	15 * (**)	12,350

* Positioning by GPS only i.e. inaccurate positioning of vertical profiles

** Positioning by DGPS

Table 3.3 Discharge calculations by velocity-area method

o Suspended sediment transport

Suspended sediment concentration profiles by point sampling are included in Volume II.

A few examples of data presentation for the left channel of Jamuna River are shown in the figure below.

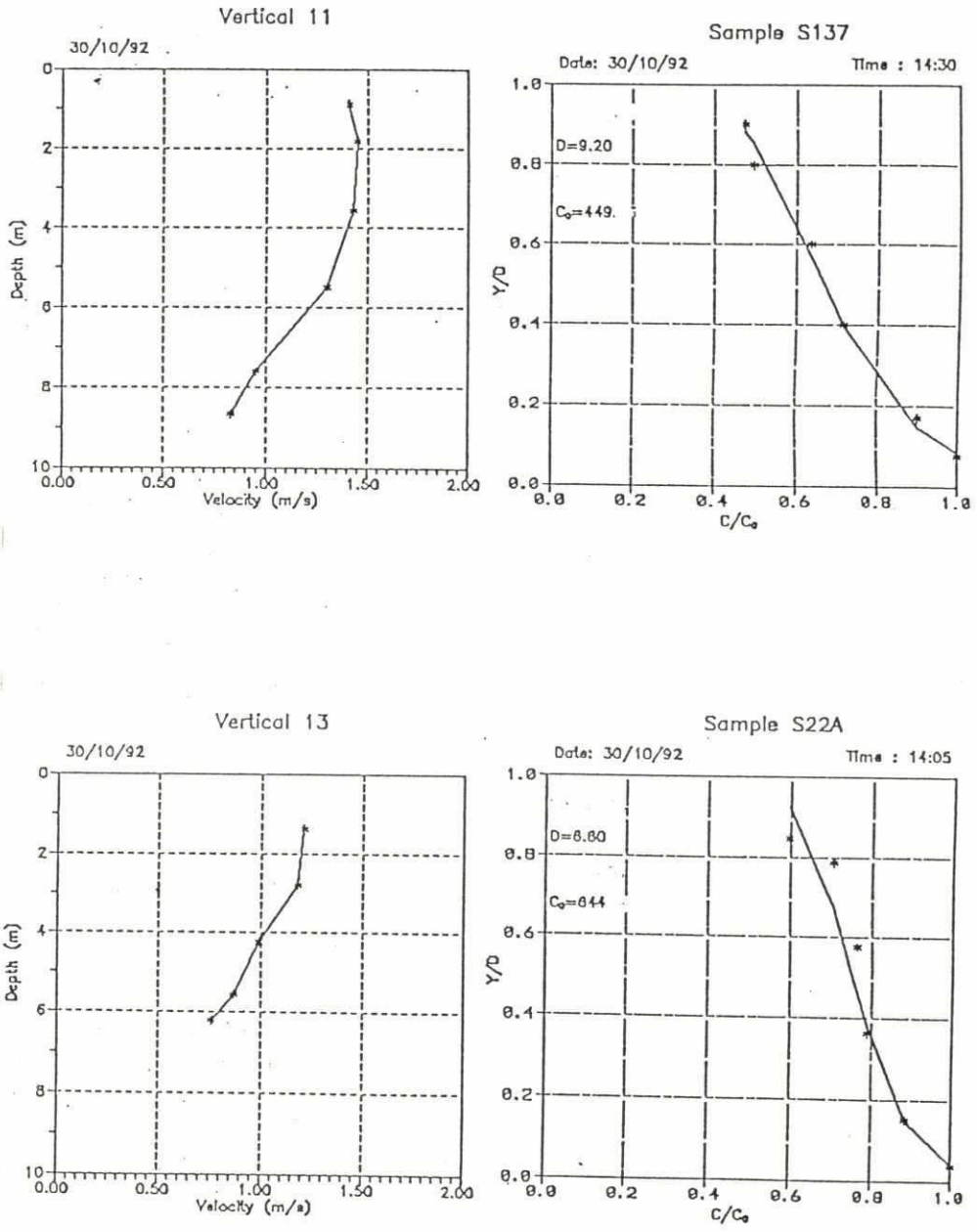


Figure 3.9 Current velocity and suspended sediment concentration profiles

The related sediment transport is also described in Volume II.

o Andreasen settling tube

Samples for determination of grain size distribution of suspended sediments have been collected in some of the profiles at the lowest sampling level close to the river-bed.

The results are summarized in table 3.5 below and grain size distribution curves as well as sampling locations are included in Volume II.

Samp No.	Collect date	Collect time	Collect depth (m)	Total depth (m)	D35 (mm)	D50 (mm)	D65 (mm)	Stnd. dev.
136C	30/10/92	13:00	9.00	9.20	0.027	0.044	0.090	4.5
143C	30/10/92	15:05	9.00	9.20	0.015	0.032	0.060	4.5
150C	30/10/92	17:00	5.20	5.40	0.015	0.026	0.052	5.5
157C	31/10/92	11:30	9.50	10.0	0.013	0.026	0.048	3.8
27A	31/10/92	12:34	6.85	9.30	0.018	0.035	0.061	5.3
28A	31/10/92	16:07	9.80	11.80	0.021	0.033	0.045	2.8
203C	03/11/92	12:30	3.50	3.70	0.012	0.017	0.025	3.0
34A	03/11/92	13:30	8.10	8.30	0.051	0.069	0.090	3.0
211C	03/11/92	13:43	2.40	2.60	0.012	0.019	0.035	3.4
218C	03/11/92	14:49	2.70	2.90	0.017	0.029	0.041	3.6
225C	03/11/92	15:40	2.00	2.20	0.019	0.028	0.042	2.9
239C	03/11/92	17:22	1.60	1.80	0.010	0.015	0.020	5.1

Table 3.5 Grain size distribution of suspended sediment samples.

The standard deviation equals 0.5 (D50/D16 + D84/D50).

As also stated elsewhere the Andreasen sampling will continue also in order to study the vertical distribution of grain sizes.

o Depth integrated suspended sediment samples

So far only a few depth integrated samples have been collected for comparative analysis. The future need will be further investigated and more samples will be taken.

The results are shown in Figure 3.10 below.

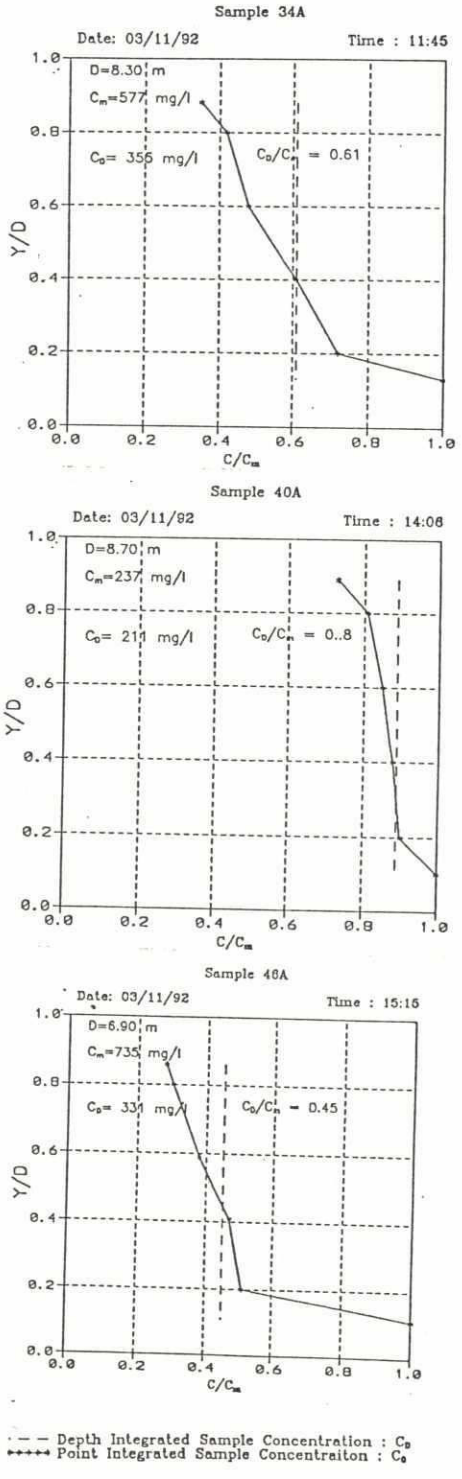


Figure 3.10 Integrated suspended sediment samples

Bed load measurements

o Helley-Smith bed load samples

Also bed load samples have been collected around some of the measuring verticals for analysis of bed load transport. Mostly three samples were taken around one vertical as indicated alongside Table 3.7.

The results are summarized in Table 3.7 below and the related grain size distribution curves are included in Volume II.

Collect date	Collect Time	Total weight (g)	Transport rate (kg/ms)	D35 (mm)	D50 (mm)	D65 (mm)	Stnd. dev.
30/10/92	15:30	124	0.0067	0.280	0.325	0.350	1.5
	15:35	336	0.0370	0.158	0.191	0.232	1.6
	16:00	690	0.0377	0.213	0.268	0.326	1.5
31/10/92	11:45	41	0.0022	0.300	0.350	0.400	1.3
	12:00	57	0.0031	0.300	0.350	0.400	1.3
	12:10	486	0.0265	0.142	0.164	0.190	1.4
31/10/92	16:15	361	0.0197	0.319	0.357	0.399	1.3
	16:30	437	0.0238	0.313	0.351	0.394	1.3
	16:45	43	0.0023	0.315	0.352	0.393	1.3
03/11/92	12:50	96	0.0052	0.089	0.108	0.137	1.9
	13:00	13	0.0010	0.199	0.269	0.330	1.7
03/11/92	14:40	875	0.0478	0.280	0.324	0.374	1.5
	14:45	598	0.0327	0.304	0.346	0.395	1.3
	14:50	143	0.0078	0.288	0.329	0.376	1.3
03/11/92	16:30	42	0.0050	0.208	0.275	0.333	1.7

Table 3.7 Grain size distribution of bed load material

In spite of a very careful and accurate performance of the measurements the results show a large scatter. The reasons for these differences will be further investigated and more samples will be needed to achieve any firm conclusion.

3.2 Tests gauging in December 1992

3.2.1 Background

Due to the fact that the test gaugings in October were done in moderate flow and could not be executed completely (see the beginning of this chapter), problems were encountered to select the complete field equipment configuration for Phase 2. In an attempt not to delay the project more than necessary, the consultant proposed to carry out some additional field tests in the lower sections of River Meghna. Here the tidal conditions were expected to generate high currents and thereby high suspended sediment concentrations during spring tide, which might be comparable with the conditions at Bahadurabad in monsoon flow conditions.

During the test gauging in October it turned out that one of the critical parameters in the survey operation was the performance of the combined current string/suction cable (umbilical) which had showed strong tendencies of vibration in the prevailing flow conditions. The consultant expects to solve the problem by adding some kind of fairing which eliminates the vortexes inducing the oscillations.

According to experience from other countries the ADCP performance is expected to become critical in terms of acoustic contact with the river bottom in high sediment concentrations.

Therefore the test gauging in December focused on the performance of the ADCP in high sediment concentrations.

A brief proposal on additional testing was forwarded on 28 November 1992 and the measurements were carried out on 14 - 24 December 1992.

3.2.2 Objective

The main objective of the additional field tests was to support decisions regarding final selection of survey equipment configuration.

A timely selection of hardware was desired to avoid substantial delays in the measuring programme as mentioned earlier. It was questionable whether these decisions could be taken from the results of the field tests of October 1992 (no high flow). Waiting for the results of the final field tests during the 1993 monsoon (high flow conditions) will cause considerable delays. Hence, the additional field tests were proposed, attempting to overcome these problems.

Conditions on site

A testing site should be found where the flow conditions would be comparable with the specified high flow conditions. Velocities up to 3 m/s and sediment concentrations up to 2000 ppm were sought. These conditions could not fully be met. However, in the tidal rivers, especially the desired sediment concentrations were expected to be found.

3.2.3 Measurement Programme

The original test measurement programme contained in principle the same measurement disciplines as the original programme carried out in Jamuna River at Bahadurabad cross-section by the end of October but should this time focus on detection of areas with high sediment concentrations. It also involved the entire survey spread including the survey vessels DHA and DHC.

The programme included:

- a rather detailed bathymetric survey for determination of a suitable test gauging cross-section
- some preliminary ADCP crossings covering a river stretch of 1-2 km in order to obtain a size of order of prevailing current velocities and distributions
- a test gauging including current profiling by S4 and suspended sediment profiling by sampling and turbidity measurements. The number of verticals would be selected on site based on distributions within the cross-section recorded by the EMF and ADCP
- function test with the side scan sonar in an alternative area with some sand dunes
- during the tests the anchoring procedure would be monitored closely especially with respect to recovery of anchors. Alternative anchors and supplementary moorings may have to be introduced

Upon arrival at the sites in the middle of the spring tidal period, again the flow conditions turned out to be lower than expected and the planned programme had to be changed drastically and cover a much wider area as described below.

3.2.4 Measurement Procedures

Individual measurement procedures were the same as applied in the previous test gauging in October and described in Chapter 3.1.3.

The December campaign covered the Lower Padma and Meghna between the existing BWDB discharge cross-section at Mawa and 60 km downstream of Chandpur.

Altogether 7 cross-sections were measured and some of them several times in order to catch the peak flow conditions (tidal). Suspended sediment samplings, turbidity readings and manual current profilings were carried out in selected critical areas.

3.2.5 Results

- Maximum velocities of 1.5 m/s were encountered
- Maximum suspended sediment concentrations of 1300 - 1700 mg/l were found
- Some critical conditions were found in a sand dune area where the ADCP lost bottom track while staying on anchor
- For further results reference is made to Volume II

4. Tentative selection and comparison of survey techniques

4.1 Pre-selection in 1991 according to ToR and Technical Proposal

In the ToR (FAP 24, 20 October 1992) the consultant is requested to collect reliable all season hydrological and morphological data at key locations at the country's main river systems with emphasis given to the high water measurements during flood season introducing improved or new technology where appropriate.

Consequently the selection of alternatives in terms of instruments and methods were based on:

- o Overcoming the drawbacks of the presently applied traditional techniques (especially the ones encountered in the monsoon season)
- o Reducing the uncertainties, especially concerning the discharge measurements, by limiting the main sources of error with respect to:
  - unsteady positioning of current meter
  - inaccurate horizontal and vertical positioning
  - inaccurate measurement of flow direction
  - spatial errors (too less measuring points in the cross-section)
  - unsteady flow (flow variations during too long measurements)

The pre-selection of techniques resulted in the recommendation of a series of alternative methods and instruments to be tested in the first phase of the project. For further background information on the previous selection of techniques reference is made to Consultants Technical Proposals of September 1991 (Delft-DHI, 3 October 1991) and February 1992 (Delft-DHI, 22 February 1992) and the Inception Report (FAP 24, 20 October 1992). Results of the pre-selection are further described in the following.

4.2 Reference and recommended method

The following table summarizes the techniques of different measurements and equipment to be used for the "reference method" and the "recommended method".

Methodology	Reference		Recommended	
Measurement	a	b	c	d
Positioning	Sextant + anchoring	DGPS station-air on engine	DGPS	DGPS
Discharge	Area-velocity method	Area-velocity method	Moving boat	Moving boat
- Velocity	Propeller	EMF	EMF	EMF + ADCP
- Direction	Floats			
- Area	Echo-sounder	Echo-sounder	Echo-sounder	Echo-sounder
- Water-level	Water-level gauge	Pressure cell	Pressure cell + wave height	
- Suspended sediment	Water sample	Pumping	Optical + ref. samples (pumping)	Optical + ref. samples (pumping) + ADCP
Bed load	Dune tracking with dual frequency echo-sounder	Dune tracking with dual frequency echo-sounder	Dune tracking with dual frequency echo-sounder	Dune tracking + side scan + direct sampling
Bathymetry	Echo-sounder	Echo-sounder	Echo-sounder single and dual frequency	Echo-sounder single and dual frequency

Table 4.1 Measuring methods

After the final test measurements, to be done in the monsoon season of 1993, the consultants, along with FPCO, will finalize the selection on the basis of:

- o Suitability of application under extreme conditions of Bangladesh
- o Rapidity of performance and relative accuracy and reliability of the data obtained

The consultant wants to state that the selected techniques to fulfill the FAP 24 objectives are not necessarily the same as the sustainable techniques envisaged for the Bangladeshi organizations. This may be caused by the different objectives asking for different accuracies.

For the final selection of the sustainable techniques other aspects have to be elaborated such as:

- o The economy of the techniques
- o Repair (spares) availability and maintenance situation
- o Timing of implementation
- o Training requirement

Consequently the FAP 24 techniques and the sustainable techniques are considered to be different issues to be developed separately, also in terms of timing.

In order to carry out the reference as well as the recommended method, following equipment has been installed aboard the survey vessels :

EQUIPMENT	VESSEL A	VESSEL C	ALU CRAFT
Positioning System:			
* DGPS	x	x	x
Current and discharge measurement:			
* MBM using EMF and ADCP	x		
* Current recording:			
OTT recorder	x		
S4 recorder	x	x	x
* Float tracking	x	x	x
Echo-sounding:			
* Elac Laz 4420 (Dual frequency)	x		
* Simrad EA 300 P (Single frequency)		x	x
Side Scan Sonar:			
* EG & G Model 260	x		
Suspended sediment measurements:			
* Sampling into bottles	x	x	(x)
* Integrated bottom sampler	x		
* Turbidity recordings (MEX 3)	x		
Bed load transport measurements			
* Helley-Smith trap samples	x		
* Sand-dune tracking by echo sounding	x	x	x
River-bed sampling			
* Van Veen Grab	x	x	(x)
Communication			
* VHF Radios	x	x	
* Walkie Talkies	x	x	x

Table 4.2 Survey Spread Matrix

A detailed description and technical specifications of the individual instruments are provided in the original Technical Proposal and summarized in Volume II.

4.3 Status on technical performance of the survey spread

General

The existing survey spread configuration is summarized in Table 4.2 and the status on technical performance of the individual instruments and survey vessels is further described in the following.

It is the consultant's opinion that the survey spread under the prevailing environmental conditions since measurements started at Bahadurabad on 21 October 1992 in general has demonstrated a consistent performance and that in the main channel the recommended method for discharge measurements is superior to the reference method in terms of efficiency, data density and data quality.

The sediment transport gauging, involving detailed point sampling, still represents some drawback in the overall operational efficiency. This aspect will be further investigated during the coming field investigations. The aim will be to reduce the spatial density as far as feasible.

Water-level recording

Installation of permanent water-level recorders is awaiting:

- Final technical clarification of the alternative sensors to be employed
- Additional site reconnaissance for selection of measurement locations in all 11 sites

Though technical alternatives have not been offered previously, it is proposed that alternative sensors do not affect the unit rates.

Final determination of the locations in the BoQ will be carried out in collaboration with BWDB and FPCO.

Evaluation of technical alternatives in terms of acoustic or pressure sensors is taking place in February 1993. A proposal for the Bahadurabad gauge will also be submitted in February, so installation should start sometime in March.

Positioning

Experience from the field has clearly demonstrated that navigating the complex river system in itself requires a very accurate positioning system - like the actually installed DGPS - in particular during the period after the flood season, when water-levels in the rivers are falling drastically and navigation depths change rapidly.

Also from an operational safety point of view, accurate positioning is required. Sometimes the daily field measurements on the river become delayed and navigation back to the berthing site will take place during night hours in complete darkness, in which case navigation can only be based on differential GPS (DGPS).

Applicable co-ordinate systems

During the establishment of the co-ordinates for our reference station (part of our DGPS positioning system), a significant difference between provided and actual measured co-ordinates in the order of 5-600 m were found.

Based on contacts with other FAP projects the consultant understands that the final basis (datum) for determination of horizontal co-ordinates has still not been decided and therefore, the provided co-ordinates are not final either.

Outstanding clarification:

Naturally this subject shall be clarified before initiation of any comprehensive bathymetric survey work now planned to start in May this year.

Discharge measurements by ADCP and EMF (moving boat method)

Based on the experience obtained since the end of October 1992 and until now the following conclusion has been established about the technical performance and employment of the ADCP instrument:

- The combined ADCP and EMF methodology is considered to provide the highest accuracy in discharge measurements in the main channels by measuring with the highest data density within the shortest time, i.e. by establishing an "instantaneous" current distribution cross-profile with the related flow discharge
- The critical environmental parameter for the technical performance of the ADCP is the suspended sediment concentration levels close to the river-bed, which may reflect the acoustic signals from the instrument and thereby cause a loss of acoustic contact with the solid river-bed. This

phenomena was detected during the test gauging in December in a well developed sand-dune area. The recorded raw data has been analyzed by a specialist (the manufacturer) and it turned out that in the actual case the bottom track had not been lost but was superseded by reflections from the water surface. This phenomena is further investigated

In summary it may be stated that so far the consultant has not been able to find a location causing a continuous loss of bottom track with the ADCP and it is therefore expected that the instrument will function in conditions close to peak flood levels as well.

However, the consultant agrees that this has to be tested at peak flow levels in the coming flood season as planned. Irrespective of the outcome of this exercise it can already now be concluded that the ADCP has proven its performance in flow conditions applicable during the period November-May and thereby increased the overall discharge measurement capacity tremendously. Therefore, application of the system in tidal flows also seems attractive.

In situations where the bottom track is lost a certain percentage of the vertical current profile will yet be measured and the high horizontal measurement density will remain the same. Software has already been developed and tested to determine the vessels speed in such cases from the vessel positions measured with DGPS.

Outstanding clarifications:

This means in more specific terms that the outstanding testing will actually focus on investigating this vertical data coverage in high sediment concentrations. Also the optimum survey speed will get further attention. More precise determination of the boundaries of applicability of the ADCP will be realized by gaining more experience with the system in various flow conditions.

Velocity and suspended sediment measurements by manual profiling (velocity-area method)

The basic principles involved in these measurements in terms of instruments and equipment as well as the combined current string and suction hose (umbilical) employed for the current and suspended sediment profiling has proven its performance during prevailing conditions.

The suction pumps with adjustable capacity allows an adjustment of the in-flow velocity in the suction tube relative to the surrounding flow. The pressure sensor in the S4 current meter allows for a precise monitoring of instrument and suction levels in the water column so by careful handling suspended sediment samples can

be collected close to the river-bed (appr. 15 cm).

Outstanding clarifications:

During vertical profiling severe oscillations even disturbing some of the S4 current measurements were detected. It is the consultants intention to solve this problem by adding some kind of fairing to the umbilical eliminating the eddies causing the oscillations. This will first be tested during the coming dry season routine measurements and verified in high flow conditions in the monsoon of 1993.

Mapping of river-bed configuration by side scan sonar for detection of sand-dune patterns

The dual frequency side scan sonar system temporarily installed on board the A vessel has proven its performance under prevailing flow and sediment concentrations. An example of a typical record from the left river channel at Bahadurabad is shown in Figure 3.6. The record clearly shows the river-bed configuration with sand-dune lengths and heights as well as their relative orientation.

Outstanding clarification:

The final need for the instrument shall be determined. A part of this clarification should be to find a method for measuring the sand-dune movements by frequent surveys in a pre-selected area (as supplement to the sand-dune monitoring by echo-sounding as foreseen in the programme)

Echo-sounding

The echo-sounders have proved their performance. Until now no loss of acoustic contact with the river-bed has been observed.

Until now echo-sounding has been carried out in longitudinal- and cross-profiles - the latter mainly simultaneous with the ADCP discharge measurements. Real sand-dune monitoring for bed load transport measurements has not yet been carried out. The consultant is awaiting conditions with well developed sand-dune formations and the authorities permission to employ DGPS. Some testing in singular lines will be carried out during some of the dry season routine measurements.

Bed load transport measurements

As also mentioned elsewhere only the Helley-Smith trap sampler has been tested

until now. It is the consultants conclusion that, by careful handling, the sampler performs very well and gives reliable and consistent results. It is expected that the instrument can be used in current velocities up to 2 m/s.

At each sampling location three samples were taken for a duration of 2 minutes each. The mesh size is 250 μm.

There has been quite some scatter in the quantities actually sampled. To some extent this is expected to reflect the nature of bed load transport. The instrument will be used during the coming dry season measurements and more experience will be obtained.

Positioning of the instrument on the river-bed must be very accurately taking presence of sand waves and general bottom contours into consideration.

Outstanding clarification:

Alternative instruments to be tested for bed load transport measurements must be determined.

Bed load transport measurements by sand-dune monitoring as mentioned above also has to be carried out.

Bed material sampling

Bed material sampling by grab (Van Veen) is a weak point in the operation so far due to prevailing current conditions. A very few samples have been taken.

Outstanding clarifications:

Testing of the USBM 54 sampler is awaiting the importing of the equipment.

Alternative sampling equipment and methods to be tested should be determined. A drag sampler is considered.

Manoeuvering and mooring of survey vessels

The survey vessels crew has been trained in survey navigation on the rivers, i.e. navigating the vessels in pre-selected straight lines (cross profiles or longitudinal lines) in varying flow conditions - in particular when crossing the rivers perpendicular to the current directions. Additional training is still required and will form a natural part of the future dry season measurements.

Apart from the C boat, mooring in the rivers has so far not been any major

problem.

Outstanding clarification:

The subject of mooring arrangements versus dynamic positioning will be studied further and alternative arrangements will be prepared for installation and implementation during the coming flood season when required.

A more powerful mooring arrangement will be installed on the C boat.

Possibilities for increasing the cruising speed of the C boat are also investigated by a professional naval architect and possible improvements will likewise be implemented prior to the coming flood season.

Data-processing office in Dhaka

The sediment laboratory and the hardware for the data-processing office in Dhaka has been installed. All the specified software has also been implemented and is functioning.

The final presentation framework will still be subject for discussion for some time between the users including BWDB and FPCO.

4.4 Comparison of measurement results

The results of the measurements have been analyzed. Special attention was given to the comparable measuring results. The objectives of the comparison are:

- To check the reliability (deviating results ask for further investigations)
- To assess in how far instruments and methods may replace each other
- To ultimately achieve an optimal combination of techniques as well as measurement coverage density

The comparison emphasized on:

- Ott propeller current meter versus S4 and ADCP
- Ott versus EMF + ADCP
- Echo-sounder versus ADCP bathymetric cross-profile
- Discharge by velocity-area method versus ADCP + EMF discharge measurements. Comparison between different measurement densities will be included in this exercise
- Turbidity measurements versus suspended sediment sampling supplemented with Andreasen settling tube analysis
- Helley-Smith bed load sampling versus suspended sediment sampling near

the river-bed

- Suspended sediment profile by point sampling versus integrated sampling

4.4.1 Ott propellers versus S4 and ADCP

The Ott propeller current meter measures the current velocity by counting propeller revolutions and in the actual case 300 seconds duration mean current velocities with record of sampling for every 50 seconds interval have been measured.

The S4 electromagnetic current meter records the current velocity and direction continuously by sampling twice per second and thereby provide a detailed record including current fluctuations. 50 seconds mean values are also calculated.

During the measurements with Ott and S4, the velocities were also measured with the ADCP for comparison.

A typical S4 record is shown in Figure 4.1 and a comparison of results from the first inter-calibration exercise in Bahadurabad cross-section is shown in Figure 4.2.

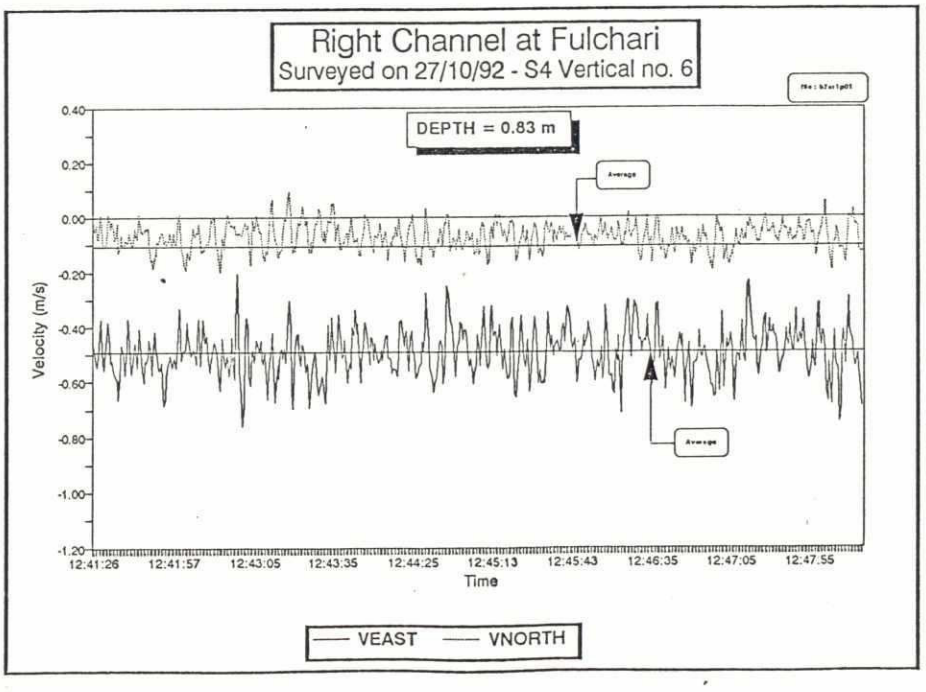


Figure 4.1 Typical S4 current recording

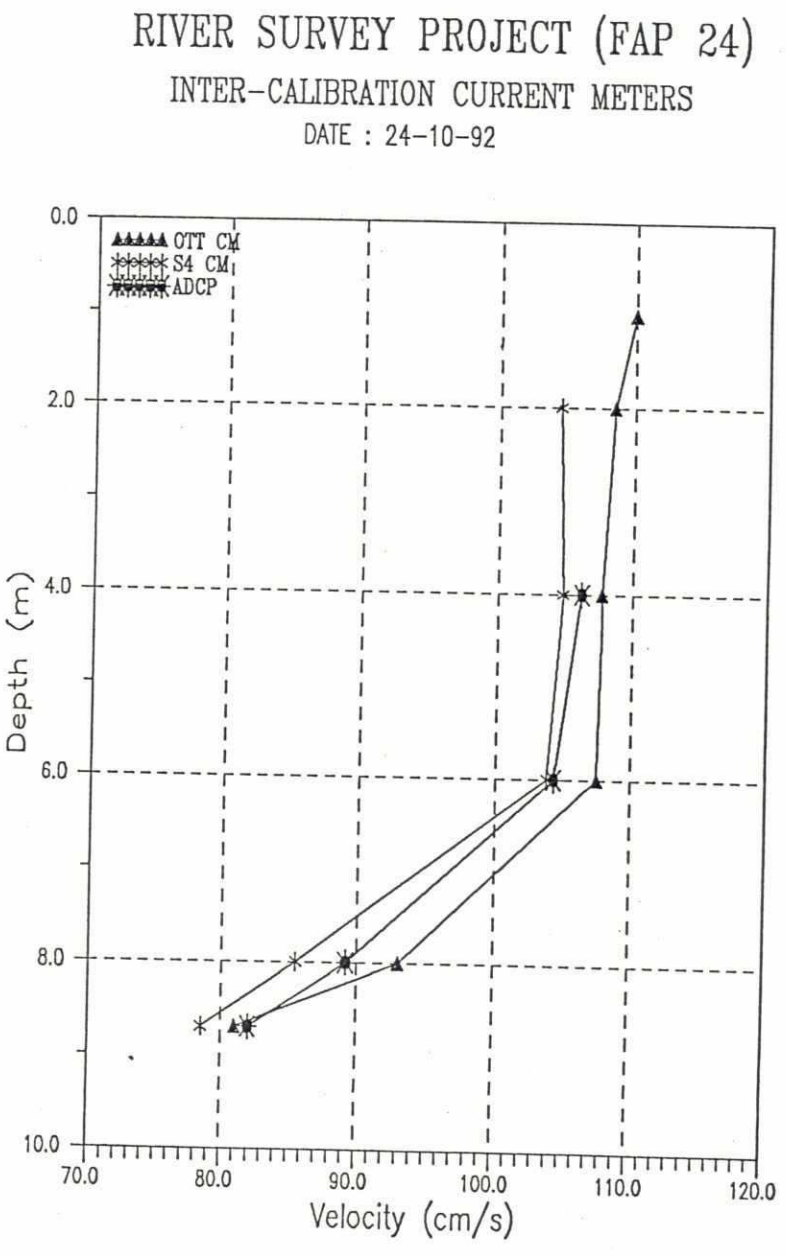


Figure 4.2 Inter-calibration of current meters used during the test gauging on 24 October 1992

The inter-calibration showed consistent results in mid flow conditions and it was concluded to proceed with the S4 meter for current profiling during the lean season.

4.4.2 Ott versus EMF and ADCP combined

Simultaneous profiling with the Ott current meter and the EMF and ADCP recorder has been carried out at several occasions.

A typical comparative profile is shown in Figure 4.3.

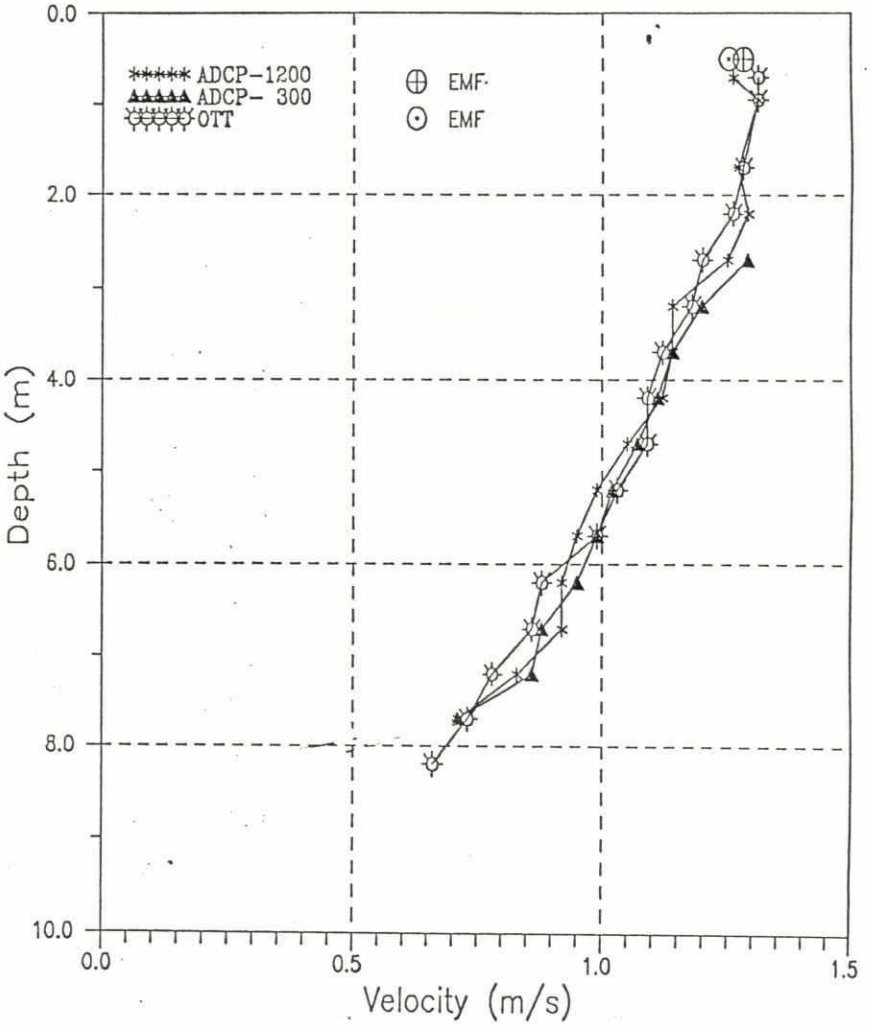


Figure 4.3 Intercalibration of current meters including the EMF

The intercalibration showed consistent results and it was concluded to proceed with the combined instrument configuration of EMF and ADCP for flow discharge measurements. The velocities at the surface (minor differences) will be investigated further. The same applies to the off-line calculation of the ADCP profile close to the river bed.

4.4.3 Echo-sounder versus ADCP bathymetric cross-profile

As a matter of verification simultaneous echo-sounder and ADCP cross-profiles (on-line recording) have been plotted. The results show remarkable good agreement.

The profiles show a horizontal displacement in the order of 10 m, which is caused by the sampling procedure in the ADCP data-processor.

The echo-sounder profile is based on a dense sampling intensity (one sample for every second) and represents the real profile in details.

The ADCP measures a complete current vertical profile and the corresponding depth (singular) for every 5-6 seconds corresponding to 8-10 m sailing distance and therefore shows a displaced profile. It may be observed that when the survey speed becomes low, as in the case of approaching the river banks, the horizontal displacement becomes negligible, as shown at the left river bank on Figure 4.4 below.

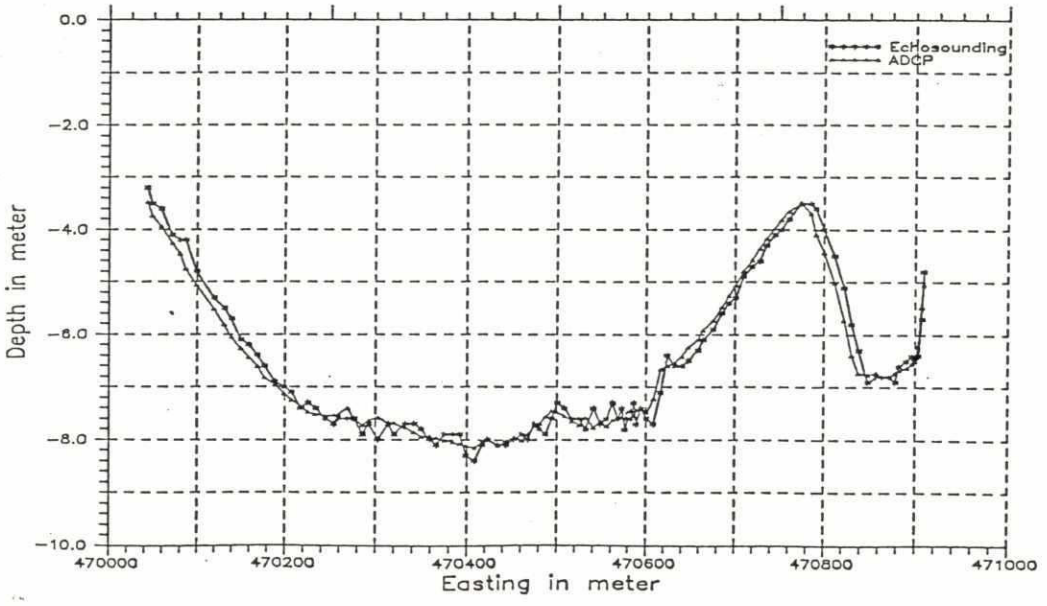


Figure 4.4 Simultaneous echo-sounder and ADCP profile

The ADCP cross-profile is not really used for any calculations. In the actual discharge calculations (off-line) the echo-sounder's real profile is used instead.

The sectional areas of each cross profile are the same.

The vertical differences may partly be caused by general river-bed configurations and partly by the different integration time per depth measurement (ADCP profile is more smoothened).

4.4.4 Discharge calculation by velocity-area method versus ADCP +EMF discharge measurements

The discharge calculation using the velocity area method and the related manual current profiles has been compared with a series of discharge measurements with the combined configuration of ADCP and EMF.

The results are summarized in Table 4.3 below for two series of measurements.

Date	Location	Discharge in m^3/s	
		Velocity area method	ADCP+EMF measurements
26 - 27/10/92	Right Channel	7,700	7,400*
29 - 31/10/92	Left Channel	12,350	11,200*

* Mean value of 3 and 8 discharge measurements respectively.

Table 4.3 Calculated and measured discharge.

The results are still subject to some analysis. The effect of the inaccurate positions of the current profiles used in the calculations for the velocity-area method will be investigated and included in Volume II.

4.4.5 Turbidity measurements versus suspended sediment sampling.

During the test gauging in Jamuna River a calibration of the turbidity meter installed on the A boat was carried out. The results shown in Figure 4.5 below are very consistent.

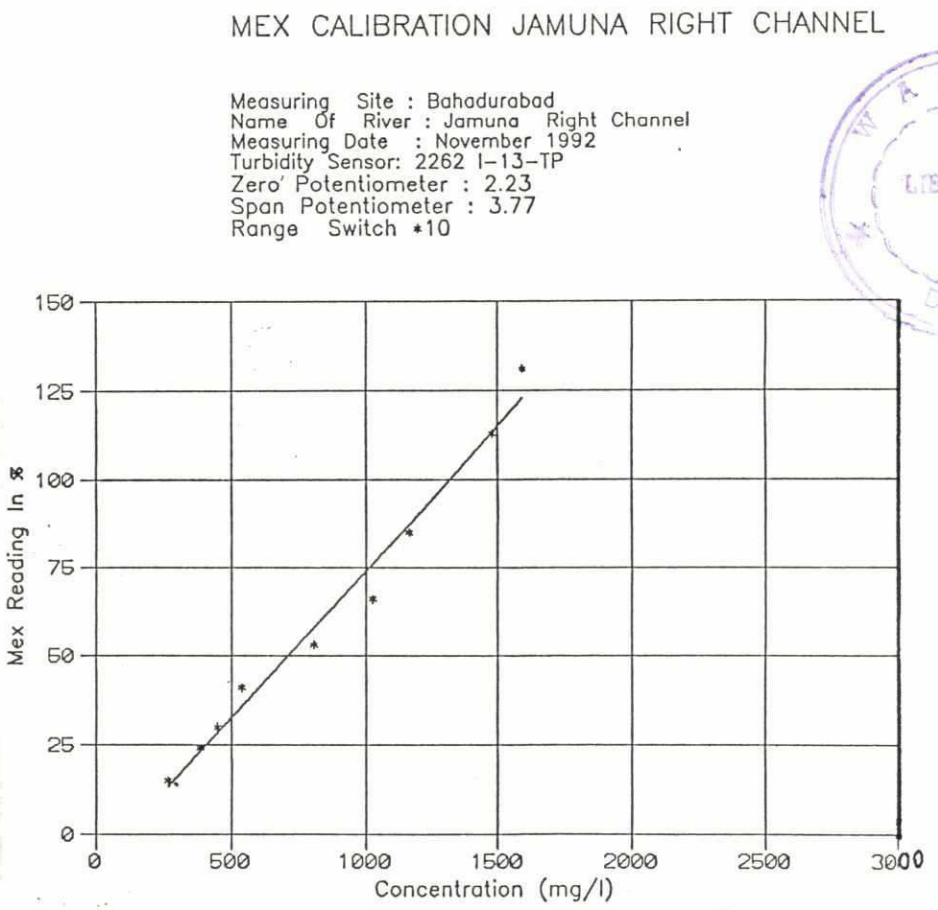


Figure 4.5 Calibration of MEX turbidity meter installed on the DHA.

Since the test gauging, several simultaneous turbidity measurements and suspended sediment sampling have been carried out at various locations. The results are shown in Volume II. Ultimately the calibrations will be correlated (if possible) to the sediment characteristics.

4.4.6 Helley - Smith bed load sampling versus suspended sediment sampling.

The entrance height of the Helley - Smith sampler is 0.076 m. The considered suspended sediments samples were taken only 0.2 m above the river bed. Yet, the bed load samples (D50) are in the 100 - 350 μm range, whereas the suspended load samples (D50) are in the 20 - 70 μm range, see sub-section 3.1.4. This indicates that there is hardly any bed material found in the suspended load transport. This holds obviously for the observed location in the present lean season conditions. Nevertheless it seems an important issue to be considered in further planning of measurements and analysis.

4.4.7 Suspended sediment profile by point sampling versus integrated sampling

Until now, only a few integrated suspended sediment samples have been collected. Additional sampling will be included in the future sampling programme in order to increase the data basis for comparison. The integrated concentration profile will also be compared with the related turbidity readings.

4.5 Tentative Selection

Based on the experience gained so far a tentative selection of techniques to be applied in phase 2 of the River Survey Project can be made.

A final selection is envisaged at the end of the monsoon of 1993. The tentative selection is summarized as follows:

o Vessels

A third survey vessel is envisaged. In size she should in principle be in between the two vessels available at the moment. Desired characteristics

-	type	:	catamaran
-	L	:	~ 35 ft
-	B	:	~ 20 ft
-	D	:	~ 2 ft
-	cruising speed	:	~ 16 knots fully laden.

One (may be two) small boats (inflatable or aluminium) provided with outboard engines and measuring frames

o Positioning
The positioning systems envisaged for phase 2 are :
- GPS for reconnaissance work only
- DGPS for other survey like bathymetry and discharge measurements, etc

Optimization is directed towards minimizing anchoring

o Flow measurements
As far as justified (depending on objective and related accuracy) using EMF with moving boat method in minor channels.

In main channels supplemented with ADCP (in fact combined ADCP+EMF)

In minor channels and areas with too less water depth for the ADCP, more detailed data to be measured with an S4 or an Ott propeller current meter.

Optimization is directed towards maximum use of the EMF+ADCP/ moving boat technique also in tidal areas.

o Suspended sediment
To be measured with a combination of optical turbidity profiling and pump bottle sampling.

Optimization is directed to minimize number of pump-bottle samples.

o Bed load
In the lean season direct sampling (Helley - Smith).

In the flood season dune tracking (side-scan and echo-sounding)

Optimization is directed towards establishing suspended load / bed load relations to minimize bed load measurements activities.

5. Hydrological study

5.1 Review of existing information

In order to gather useful background information on existing hydrological studies, databases, analysis methods etc. relevant for the FAP 24 studies of the main rivers, a comprehensive survey of related projects and organizations was made by visiting the various offices.

Reports and available data have been collected and reviewed and information on current procedures for collection, processing, checking and storage of hydrological data has been obtained.

The agencies visited are:

- Directorate of Surface Water Hydrology I and II (SWH-I and SWH-II) of the Bangladesh Water Development Board (BWDB)
- Flood Modelling and Management (FAP 25)
- Surface Water Modelling Center (SWMC)
- River Training Studies of the Brahmaputra River (BRTS, FAP 1)
- Bank Protection and River Training (AFPM) Pilot Project (FAP 21/22)
- Jamuna Bridge Project
- Bangladesh Inland Water Transport Authority (BIWTA)
- Water Resources Planning Organization (WARPO)

A description of the information received and the reports reviewed will be enclosed in Volume III.

5.2 Collection and processing of historical data

6 discharge/water-level stations (Q/H-stations) in the main rivers are being used for studies, i.e.:

- Bahadurabad
- Hardinge Bridge
- Baruria
- Mawa
- Bhairab Bazar
- Gorai Railway Bridge

Data required for the hydrological studies are:

- Observed discharges and corresponding water-levels (OD) for the 6 Q/H-stations

- o Mean daily discharges (MDD) for the 6 Q/H-stations
- o Mean daily water-levels (MDWL) for the 6 Q/H-stations and adjacent water-level stations in the main rivers

These data are required for all the years in the period 1965/67 - 1991/92 and 1992/1993 for as far as possible.

Most data could be collected from BWDB and FAP 25. A summary of available data at FAP 24 will be included in Volume III. This will also show that some data still have to be procured.

The available data have been transferred to a HYMOS database for further processing. Also spreadsheet programs are being used for data-processing.

5.3 Preliminary results

5.3.1 Analysis of the Anwesha survey in September 1992 at Bahadurabad

In September of last year discharge measurements were carried out with ms. Anwesha at Bahadurabad. A detailed report of this additional survey has been made (FAP 24, 31 October 1992).

The measurements have been analysed and a substantial difference was found between the discharge measured at Bahadurabad on 15-16 and 19 September and the discharge derived from both the updated rating curve for 1992 based on the available BWDB Q/H measurements during the 1992 monsoon (ref. Figure 5.1) and the discharge according to BWDB rating curve for 1989. The measured discharge on 15-16 September was 25,600 m^3/s at a water-level of 17.82 m/PWD. The rating curve for 1992 gives a discharge of approximately 34,500 m^3/s at that water-level.

An explanation for this difference has been sought and the conclusions of this study will be presented here. Further details will be given in Volume III.

The tentative conclusions are:

- o There are a number of potential sources for the observed differences in discharge, but it is believed that the most important reason is the different measuring method applied. At that time both BWDB and FAP 24 applied traditional techniques using propeller current meters and the velocity-area method. The main difference was that during the Anwesha survey detailed flow direction

measurements were performed. Whereas BWDB at Bahadurabad is only using surface floats and does not have the required equipment for measuring flow directions below the water surface

- o Another source of deviation may be the measurements of cross-section profile depths by current meter only at the selected verticals instead of echo-sounding the whole cross-section.
- o Both the procedures described above will usually result in too high discharge estimates (FAP 25, 1992). However, it is difficult to make any firm conclusion on the exact reasons for the observed deviation because the Anwesha survey and the BWDB measurements were not made in the same river cross-section and not on the same day. For further analysis of the BWDB measurement techniques and possible sources of errors it is therefore recommended that further comparisons and analysis be based on simultaneous measurements in the same cross-section by BWDB and FAP 24, preferably over a range of water-levels

5.3.2 Analysis of rating curves

Improved method for analysis of rating curves

Based on the BWDB Q/H-measurements for two stations at the main rivers (Bahadurabad at the Jamuna and Hardinge Bridge at the Ganges) an improved method for rating curve analysis has been worked out. As will be described in the review of existing information in Volume III of this report, both BWBD and FAP 25 assume a fixed offset (H_0) for the whole rating curve. This is usually not the case and it is not according to the internationally acknowledged standard method (ISO standard) for development of rating curves with more than one segment (ISO, 1982 and MWEM, 1979).

The assumption of one fixed offset often leads to fitting of straight lines through Q/H-points forming a curve on the log/log-plots (for the higher segment(s)) which may lead to very uncertain extrapolations and thus, for stations with a bad coverage in the high flow ranges, to wrong estimates of the high flood discharges in particular.

Volume III will give full details of the consultant's recommended procedure for rating curve analysis.

Varying rating curves

For a long time BWBD and Fap 25 have been aware of considerable variation in time of the yearly rating curves for the main rivers of

Bangladesh. FAP 25 did not analyse the exact reasons for these annual shifts. Morphological changes, systematic errors in discharge measurements and long term shifts in gauge locations were held responsible.

During analysis of the annual rating curve for Bahadurabad a major shift of the measured Q/H-points was observed after the flood of August 1988. This matter will be discussed in detail in Volume III. Only a few remarks will be made here.

Before the 1988 flood the Q/H-points and the fitted annual rating curves vary up and down within a limited range from year to year. On the other hand, almost all Q/H-measurements in the period 1988-1992 after that flood are lying consistently lower, particularly in the high range. That means that the rating curves for these years indicate higher discharges at the same water-level than the rating curves from before the 1988-flood (ref. Figure 5.2 and 5.3).

Preliminary analysis (ref. Volume III) indicate that the Q/H-measurements at Bahadurabad, especially in the mid and high flow ranges, since the 1988 flood, may be inadequate, resulting in far too high discharge time series for the years 1988-1992 (probably 20-40% overestimate). This is illustrated by Figure 5.4 showing increasing flood volumes over the last couple of years, which is rather unlikely.

An overestimate might be explained by a dramatic local change of plan-forms, channel pattern and cross-section during the high flood of 1988, which could have resulted in a skewer velocity distribution. As BWDB does not have the equipment at Bahadurabad for measurement of the flow direction at each point of the cross-section, the effect of such a skew velocity distribution on the discharge estimates may have become much more important. It would imply that BWDB's procedure for correction for flow directions, based on surface floats only, may give much more overestimates now than before the 1988 flood. Obviously these suppositions need further investigations before firm conclusions can be drawn. It is therefore proposed to review the existing site and execute measurements, emphasizing flow angles in the mid and the higher flow ranges.

The Q/H-measurements at Bahadurabad, and thus the resulting discharge time series, for all the years before the 1988 flood seem much more reliable and consistent than after that flood. Therefore the approach to develop annual rating curves based on the actual Q/H-measurements seems justified for all the years before 1988. As far as can be concluded

at this moment, development of rating curves for other stations, based on Q/H-measurements, seems to be justified for all the years up to 1991. However, rating curve analysis for other stations is still in process.

It further implies that the various statistical analysis carried out by FAP 25 in the Flood Hydrology Study on basis of long term data series up to 1988 will not be affected significantly.

It is however recommended that BWDB's discharge time series from Bahadurabad for the period 1988-1991 (1992) will not be used uncritically as they might be overestimated by 20-40%. At the present stage it would probably be better, as a first "best estimate", to establish new discharge time series for 1988-1991 (1992) for Bahadurabad based on the FAP 24 rating curve for 1987.

It is also recommended that BWDB will be supplied with the required equipment for measurement of flow direction at each point of their cross-section at Bahadurabad as soon as possible.

Status on development of new rating curves

- Bahadurabad:
  Annual rating curves have bee developed for all years from 1966 to 1992 based on the improved method as mentioned above. However, for the years 1988-1992 as a first "best estimate" it will be better to use the 1987 rating curve for generating discharge time series. The 1987 rating curve is very similar to the rating curve for 1988 based only on Q/H-measurements from before the August flood
- Hardinge Bridge:
  New annual rating curves have been developed for all years in the period 1966-1991. Analysis of these rating curves have not yet been carried out
- Baruria:
  Development of new annual rating curves is in process

Rating curves for Mawa, Bhairab Bazar and Gorai Railway Bridge still have to be developed.

5.3.3 Checking and correction of water-level time series

Based on FAP 25 guidelines (FAP 25, 1992) BWDB water-level time series are currently being checked at FAP 24. This is being done for the 6 Q/H-stations in the main rivers.

FAP 25 has already made some corrections in the series for Bahadurabad, Hardinge Bridge and Baruria. Some additional error detection and correction for Bahadurabad has already been initiated based on comparison with selected neighbouring water-level stations.

Comparison stations have also been selected for the other 5 Q/H-stations. Water-level time series for each station will be plotted together with the time series of their comparison stations. Also for each year plots will be made of the differences in water-level between the Q/H-stations and their neighbouring stations as well as plots of the changes in these differences.

Based on these figures errors can be detected. Corrections are mainly made by interpolation.

A more detailed description of this method will be given in Volume III.

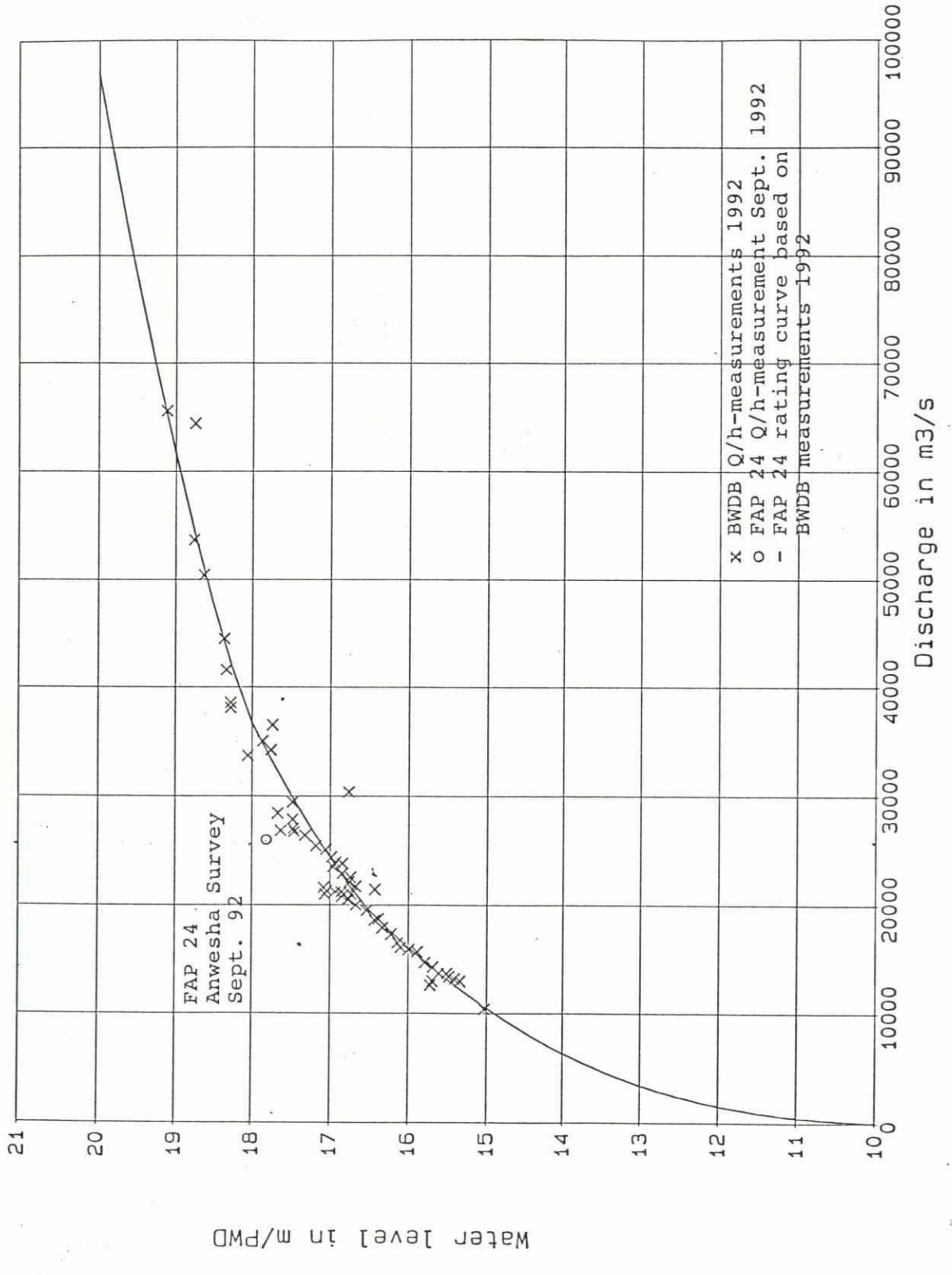
5.4 Workplan

The second stay in Bangladesh of the expatriate hydrologist is planned for April 1 - May 31, 1993. Before that period the local counterpart will carry out the following tasks:

- Collection of all data (observed discharges, mean daily discharges and mean daily water-levels) necessary to complete the database for the full period 1965-1991 (1992)
- Development of annual rating curves for all 6 Q/H-stations based on the method as described in Section 5.3.2 and Volume III for all years 1965-1991 (1992)
- Check and correction of mean daily water-levels for the 6 Q/H-stations for all years 1965-1991 (1992)
- Check and correction of mean daily water-levels for the 6 Q/H-stations for all years 1965-1991 (1992)

During the period April 1 - May 31, 1993 the following work is planned:

- Analysis of trends in discharge time series and water-level time series for the 6 Q/H-stations
- Assessment of overall uncertainties in discharge time series and water-level time series, present data as well as updated data
- Statistical analysis of discharge and water-level data (frequency analysis and extreme value analysis)
- Water-level profiles
- Planning of Phase II hydrological studies
- Reporting



FAP 24 RIVER SURVEY PROJECT Delft Hydraulics/Danish Hydraulic Institute in association with Osiris/Approtech/Hydroland DELFT-DHI		Discharge measurements and rating curve Bahadurabad 1992	
File:	Date:	1° Interim Report February 1993	Fig. 5.1
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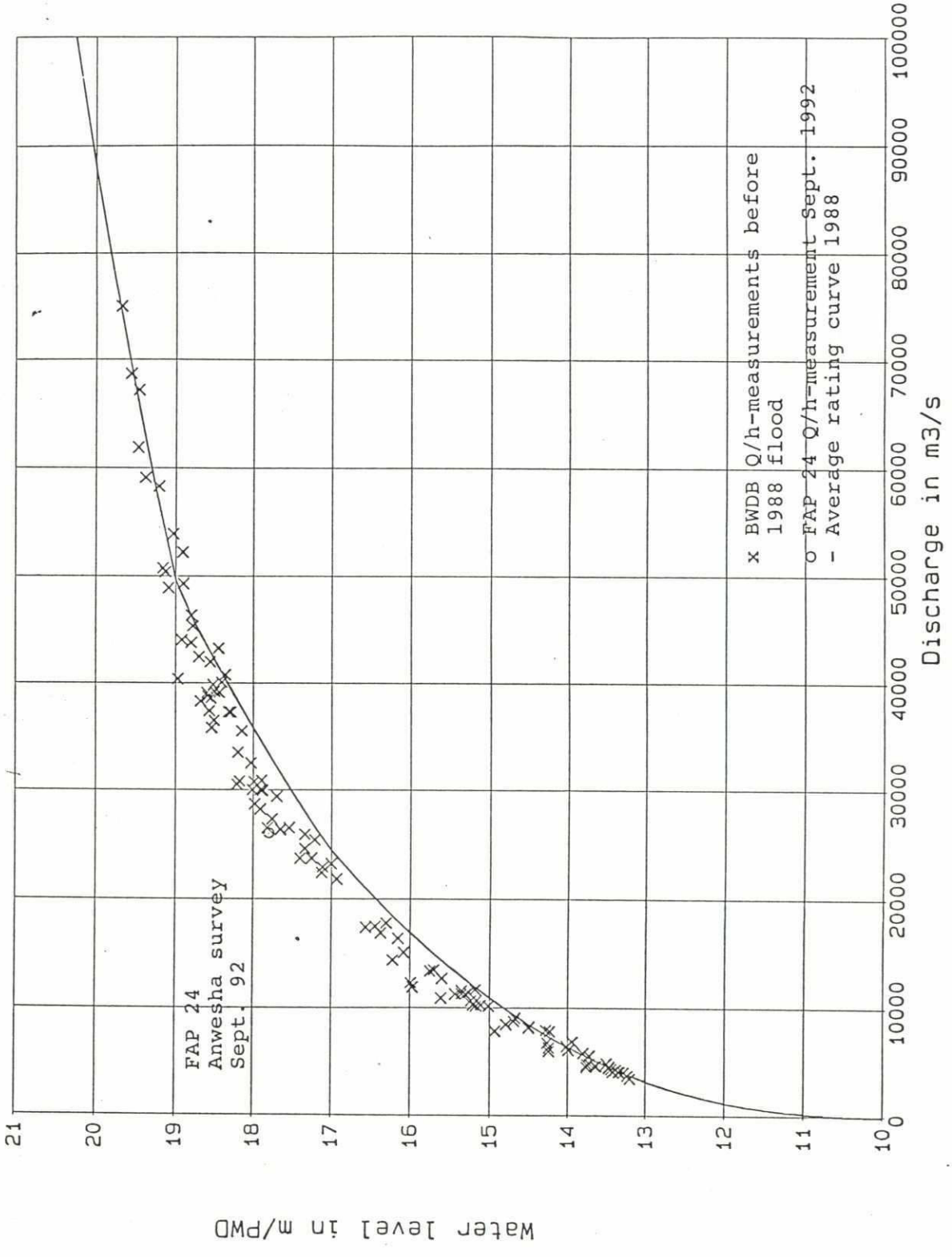

FAP 24 RIVER SURVEY PROJECT DELFT-DHI Delft Hydraulics/Danish Hydraulic Institute in association with Osiris/Approtech/Hydroland		Discharge measurements and rating curve Bahadurabad 1985 - 1988	
File:	Date:	1st Interim Report February 1993	Fig. 5.2
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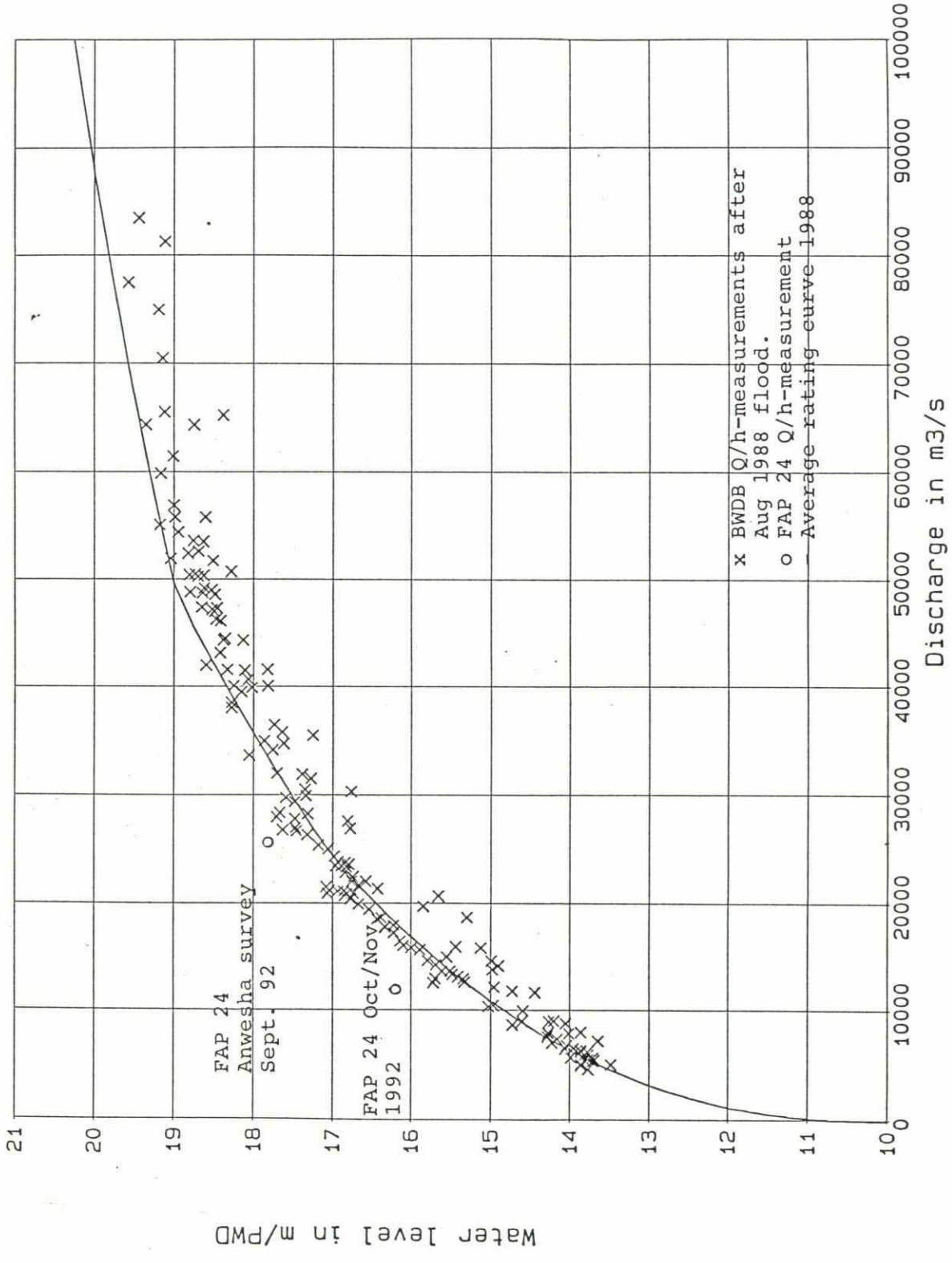
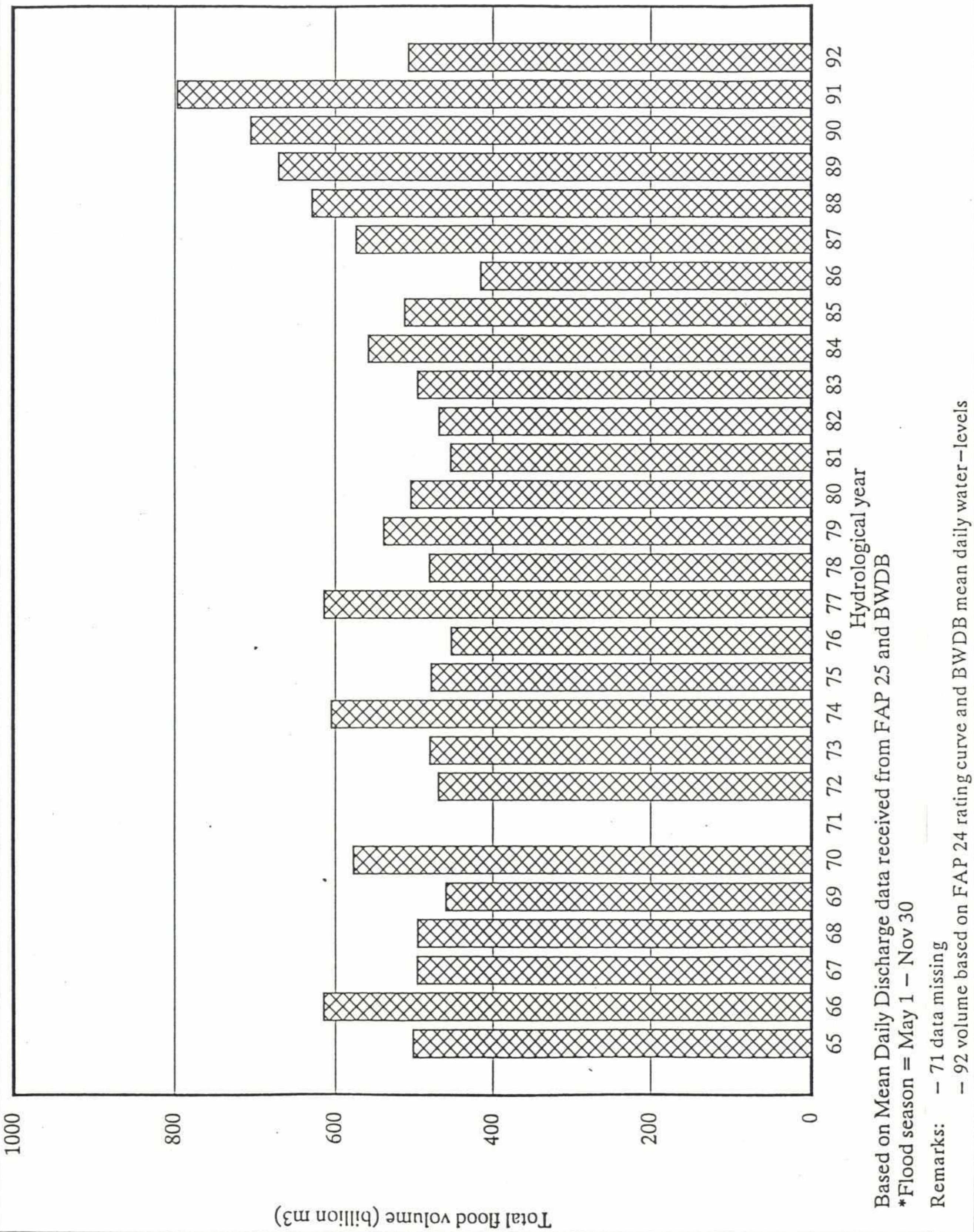


FAP 24 RIVER SURVEY PROJECT Delft Hydraulics/Danish Hydraulic Institute in association with Osiris/Approtech/Hydroland DELFT-DHI		Discharge measurements and rating curve Bahadurabad 1988 - 1992	
File:	**Date:**	1° Interim Report February 1993	**Fig.** 5.3
Scale:	**Inlt:**		



FAP 24 RIVER SURVEY PROJECT Delft Hydraulics/Danish Hydraulic Institute in association with Osiris/Approtech/Hydroland DELFT-DHI	Annual flood volumes Bahadurabad	
File: / Date:	1° Interim Report February 1993	Fig. 5.4
Scale: / Inlt:		

6. Morphological study

6.1 Introduction

Although the morphological study under Phase 1 has only started recently (as the expatriate morphologist arrived in Bangladesh in the beginning of January), here a short overview is given of the activities carried out until now. A distinction is made between the review of the available data, a review of the measuring methods used, and a review of the reports and other literature found. These are discussed in Sections 6.2 through 6.4. Furthermore the process of identifying and selecting topics for study under Phase 2 has been initiated. Some details are given in Section 6.5. One study topic has to be taken up already in Phase 1: the overall impact of the FAP's on the morphology of the main rivers. The first activities under this study topic are described in Section 6.6.

As obviously only a start could be made with the morphology study in the past three weeks and the bulk of the activities still has to be carried out, an overview of the remaining activities for Phase 1 is given in Section 6.7. Here only a summary is provided of the items listed before. More details are given in Volume III, Annexure 5.

6.2 Collection, review and assessment of available data

In Table 6.1 an overview is given of the most relevant morphological data on the main rivers in Bangladesh. Data on stages, discharges and slopes, though esssential for river morphology, are discussed in Chapter 5.

Type of data	Organization			
	BWDB	RRI	BIWTA	Others
Planform characteristics			Charts since 1966	Jamuna Bridge studies, FAP 1, FAP 9B, FAP 21/22
Bed material		Reports of size analysis		FAP 1, FAP 4 (?), FAP 9B
Cross-sections	Morphology Department since 1966			
Bed topography	Detailed soundings		Charts since 1966	BIWTAS (1989), FAP 1, FAP 21/22
Sediment transport	Hydrology 2			FAP 1
Composition of transported sediments	Hydrology 2: coarse/fine	Reports on size analysis		
Bank material				FAP 1

Table 6.1 Availibility of data on the main rivers in Bangladesh

It should be noted here that these data are not available for all rivers and for all years. Part of these data are computerized and available in databases. We are in the process of acquiring the most relevant data. For more detailed, though not yet complete, information reference is made to Volume III, Annexure 5.

6.3 Review and recommendations regarding data collection

A critical review of the data collection was started recently with checks on the sediment transport rates. Some older and more recent data were entered in a first version of the data-storage and -processing program MORDAT, that in due time can be linked to the hydrological data handling package HYMOS. First checks were carried out on these data and it was observed that there is indeed an inconsistency between the older and the more recent data, the older data showing about 4 times larger sediment transport rates at Bahadurabad. A similar observation was done during the Jamuna Bridge Study and FAP 1. We intend to investigate this discrepancy in an attempt to make maximum use of the data in the past. Similar checks will be carried out for the other stations where sediment transport is being measured.

In a further step also the various cross-sectional data will be assessed via a number of checks. In doing this due attention will be given to the bench-mark histories as available with BWDB Hydrology. In addition it will be attempted to mutually compare the cross-sections from BWDB with the soundings of BIWTA. To do this a selected set of cross-sections and soundings will be acquired and processed.

6.4 Collection, review and assessment of reports on river morphology

Over the past decades many studies have been carried out on the different main rivers in Bangladesh, mostly within the frame-work of a consultancy study regarding the feasibility of the detailed design of structures. In Table 6.2 an overview of the most relevant studies is given for the different rivers. In many of these reports the basic data as listed in Section 6.2 have been elaborated, though a formal quality check was often not carried out.

In addition a number of publications (to start with the bench-mark paper of Coleman (1969)) have been identified and these are in the process of being collected as far as relevant for the project.

6.5 Study topics

A start was made with identifying the study topics for Phase 2. During the preparation of our proposal we had already prepared a tentative list of study topics. On recent studies in which we were involved in screening recent reports published from other consultants, the tentative list was slightly extended. This list was sent to the different FAP projects which could be interested in additional studies, notably FAP 1 through FAP 6, FAP 16, FAP 17, FAP 18, FAP 20, FAP 21/22 and FAP 25, with the request to reflect on these topics.

River	Consultancy report
Ganges River	Nedeco (1968), Rehabilitation Ganges-Kobadak project (1983), FAP 4 (1993)
Brahmaputra/ Jamuna River	Nedeco (1968), JICA (1976), Jamuna Bridge (1986,1987, 1990), FAP 1, Bangladesh-Chinese Joint Investigation Team (1991),Char land study = FAP 3.1 (1992), FAP 21/22 (1992,1993)
Old Brah-maputra/Lakhya River	Nedeco (1968), FAP 3 (1993)(?), FAP 6 (199.)(?)
Dhaleswari River	Nedeco (1968), Jamuna Bridge (1990), Dhaleswari Mitigation Study
Upper Meghna River	Nedeco (1968), FAP 9B (1992)
Padma River	Nedeco (1968), FAP 9B (1992), FAP 4 (?)
Gorai River	Nedeco (1968), FAP 4 (1993)
Arial Khan/Dubaldia Rivers	Nedeco (1968), FAP 4 (1993)

Table 6.2 Most important consultancy reports dealing with the main rivers in Bangladesh

Most of the Team Leaders of the FAP projects and also SWMC were interviewed regarding their ideas on the possible study topics and surveys needed for these topics. Also FPCO and its Project Adviser will be interviewed formally and the same holds for the local and expatriate Panels of Experts of FPCO. As these interviews are still going on, no final recommendations have been derived from them. For more details reference is made to Volume III, Annexure 7.

It is stressed here that the study topics should form the basis for the establishment of a survey programme for Phase 2. Once the study topics have been established the proposed survey programme for Phase 2 will be scrutinized and if required proposals will be made for adjustments. It is remarked here that the final decision for which study topics will be included can only be made after the workshop on morphological characteristics of the main rivers in Bangladesh, probably to be held in the fall of 1993. It is felt though that around 1 July of this year some major decisions as to most of the topics have to be taken, in order to be able to plan the surveys well in advance, to buy additional instruments when required and to test these during the monsoon period of 1993. Quite some flexibility in the selection of the study topics will however be kept, even during Phase 2 itself, to be able to redirect some of the studies.

6.6 Overall impact of all FAP's

In the ToR (FAP 24, 20 October 1992) it is specifically indicated that in Phase 1 a first assessment has to be made of the overall impact of the combined FAP projects as far as their morphological characteristics is concerned. To make such an assessment it is required first of all to have a basic understanding of the morphology of the main rivers. For this it is also required to understand hydraulic conditions during floods and during lower discharges, as the hydraulic conditions trigger the morphological changes. Hence an attempt will be made to integrate all available knowledge on the hydraulics and in a second step of the morphology of the main rivers in Bangladesh. Attention will also be given to the bifurcations where the water and sediment is distributed and to overland flow as a possible sink and source in the system. In addition attention will be paid to the sedimentation of fine sediments for the present conditions.

Once such a basic understanding has been acquired - the depth of this of course depending on how well the data on the rivers match - the different scenario's for river development under FAP will be assessed as far as their impact is concerned. It is intended to do this in a two-step approach. In a first step the ultimate effects will be assessed. For the time being it is intended to use the approach which has been developed under FAP 21/22 (FAP 21/22, December 1992, Annex 1, Chapter 7). This approach has the advantage that also the effect on the planform, the braiding and meandering characteristics and on the slope can be estimated. In a second step a 1-dimensional morphological model will be applied to study the effects of all the FAP projects in combination. Discussions with SWMC are on-going to assure their assistance and to establish the main characteristics of the mathematical model to be used. For the time being a fairly simple model is inteded to be used, as it is intended to study the effect of the FAP projects in combination in more detail. It has to be remarked that it appears that a full-fledge simulation of the impact of the FAP's in combination appears to be far in excess of the study capabilities of FAP 24, even in Phase 2. Hence the recent conclusions of the CAT mission to FAP 25 calling for adding a morphological component to FAP 25 are underlined here.

An important aspect is which scenario's have to be used for the impact assessment. For the time being some scenario's as used by FAP 25 for the simulation of the hydraulic impacts will be used. In the discussions with the different FAP projects, as carried out under the activities described in Section 6.5, it is also verified to what extend the different scenario's are still a fair reflection of the current ideas within the various projects. In this respect it is important to realize that a scenario should not only comprise a number of possible natural developments and possible projects, but especially the timing of their implementation. Hence we will approach this matter in a way similar

to the Jamuna Bridge Study.

6.7 Activities in remaining part of Phase 1

The remaining activities under Phase 1 of the project can be specified as follows:

- Review of historical data on sediment transport and bed topography. Under this topic the following activities are foreseen:
  - further identification of available data (bed material, sediment transport, bed topography, planform, etc.)
  - collection of historical data as indicated above as far as deemed necessary
  - investigation into methods used in the past, including both the actual measurements and the processing
  - discussion with Hydrology staff (and Hydrography Dept BIWTA) including local personel on both aspects
  - draw preliminary conclusions as to the need for improving the measuring methods
  - store sediment data into database (MORDAT or spreadsheet programs)
  - analyse stored data as far as trends, consistency, etc. is concerned
  - prepare sediment balances
  - identify, collect and study (other) reports dealing with sediment transport, bed topography and sediment balances
  - draw conclusions as to the reliability of the historical data and their relevance for the studies to be carried out
  - suggest improvements for the BWDB and BIWTA measurements, which should be sustainable also after FAP 24 has been finalized
- Studies to determine alternative measuring methods for bed material, sediment transport and bed topography. Under this topic the following activities are foreseen:
  - determine need for improvement based on the critical review as described under the point above
  - study alternative methods for measuring sediment transport and bed topography
  - investigate possibilities and limitations of ADCP and other novel instrumentation for their potential of measuring sediment transport
  - propose improvements of present methods
  - generate ideas regarding alternative measuring methods with novel instruments

- identify studies and surveys needed to decide on the preferable measuring methods

o Identify possible study topics and propose a selection for Phase 2. Under this topic the following activities are foreseen:
  - prepare list of possible study topics, based on list in proposal
  - discuss possible topics with FPCO, BWDB, SWMC and other institutions
  - discuss possible topics with relevant FAP's and other projects in Bangladesh
  - complete list of possible topics on the basis of these discussions
  - make a priority ranking
  - make a first estimate of the time and additional survey required for each of the most highly ranked study topics
  - propose on this basis the study topics to be included in Phase 2
  - specify need for additional surveys
  - communicate with BUET, DUT, IHE and University of Leeds on their possible contribution

o Review of survey programme of Phase 2. Under this topic the following activities are foreseen:
  - assess need for additional surveys from different FAP's based on inventarisation under the point above
  - assess need for additional surveys from study topics from the point above
  - compare this with proposed survey programme and suggest changes;
  - specify particulars of bathymetric survey (area, spatial bathymetry, frequency, etc.)
  - propose tentative selection of methods to be applied this year
  - advise on the improvement of the survey capacity of BWDB and BIWTA, based on their present instruments and measuring methods

o First assessment of impact of FAP projects on the main rivers of Bangladesh. Under this topic the following activities are foreseen:
  - collect FPCO scenario's for future developments of river training etc.
  - discussion with FPCO and the other FAP's on the relevance of these scenario's and required improvements, including their phasing in time
  - select of most likely scenario's
  - study methods for assessing the impact of FAP projects
  - selection of assessment method
  - make preliminary assessment based on most likely scenario and using the selected method

- indicate sensitivity to assumptions and basic data
- specify need for additional surveys to improve understanding of river systems in Bangladesh and their response to river training

7. Training

The main objective of the training is to upgrade the institutional capabilities in Bangladesh for river hydrological and morphological data collection and studies. Training will mostly take the form of on-the-job training, but will be supplemented by seminars and workshops (FAP 24, 20 October, ToR).

In Phase 1 only initial training is envisaged and a training programme for Phase 2 needs to be developed in conjunction with the relevant organizations (ref. Technical Specifications Section 3.5).

The training programme in Phase 1 is summarized in the following schedule:

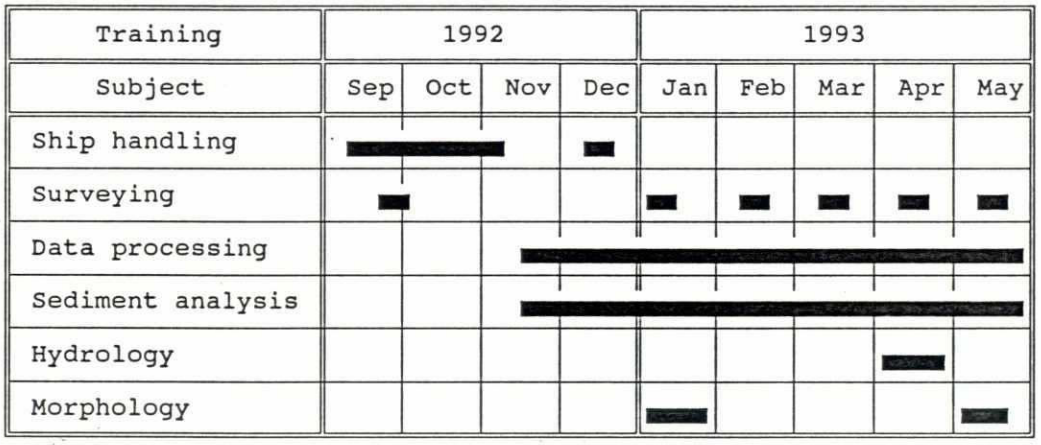


Figure 7.1 Training programme Phase 1

The training on ship handling maintenance and manoeuvreing was especially arranged for the local crew of the survey vessels.

The training on surveying, data-processing and sediment analysis is given in the form of on-the-job training, whereas the training on hydrological and morphological aspects is given in the form of lectures, workshops or seminars. For all training subjects (except the first one) invitations have been sent to and via FPCO. For further details reference is made to Volume III.

8. Workplan revisions

8.1 Introduction

For both technical and administrative reasons the mobilization for Phase 2 has to be postponed from the first half of 1993 to the lean season after the monsoon period of 1993. For details reference is made to Annexure 9. This means that a revision is required for the overall workplan and consequently also for the detailed workplan covering the period from December 1992 to June 1993.

8.2 Implications and scope of revisions

The limited equipment during the monsoon of 1993 forces a reduction of the measurements in that period. This means that the number of floods getting a 100% coverage is reduced to two (1994 and 1995 only). Therefore it is considered not to terminate the project just before the monsoon of 1996 but after peak flow of the monsoon. This means in broad terms that:

- The Phase 1 measurements are not affected. Gaugings missed in 1992 are shifted
- Between Phase 1 and Phase 2, viz. June 1 and October 31, 1993 a transition phase of five months is proposed with a mixed survey programme comprising:
  - HW test gauging
  - HW routine gaugings at all sites but with a lower frequency (about monthly at the main stations instead of fortnightly). At the end of this phase the final survey spread configuration will take place
- Phase 2 starts with a mobilization period and covers possibly three years, with a hardly affected measuring programme (which means that the first LW measurements need to be done with Phase 1 equipment only). During the last monsoon the routine gaugings aim at catching the rising phase and peak of the flood only (in 1996)

The main revisions can be summarized as follows:

- Shifting the comparative test gaugings from 1992 to 1993
- About halving the HW routine gaugings and corresponding bed load measurement in 1993
- Shifting the remaining HW routine gaugings of 1993 to 1996
- If desired, extending the project period with 5 months (about 3 months survey and 2 months demobilization provided the available resources permit)

Maintaining the number of surveys according to the BoQ.

Some secondary revisions are:

- o Further reconnaissance survey work
- o Shifting the installations of some AWLR stations from Phase 2 to Phase 1
- o Starting earlier with the bathymetric survey work (already before the floods of 1993) at one site only, in order to define the final need and optimize this type of survey work

The above listed main and secondary revisions are mainly dealing with the survey component of the project. The study and training component will be affected where they are related to the survey compontnt. Therefore the discussion on the revisions is focussing on the survey component. The revisions indicated in this section are summarized in the overall survey workplan hereafter. For more details reference is made to Annexure 9.

8.3 Revised survey workplan

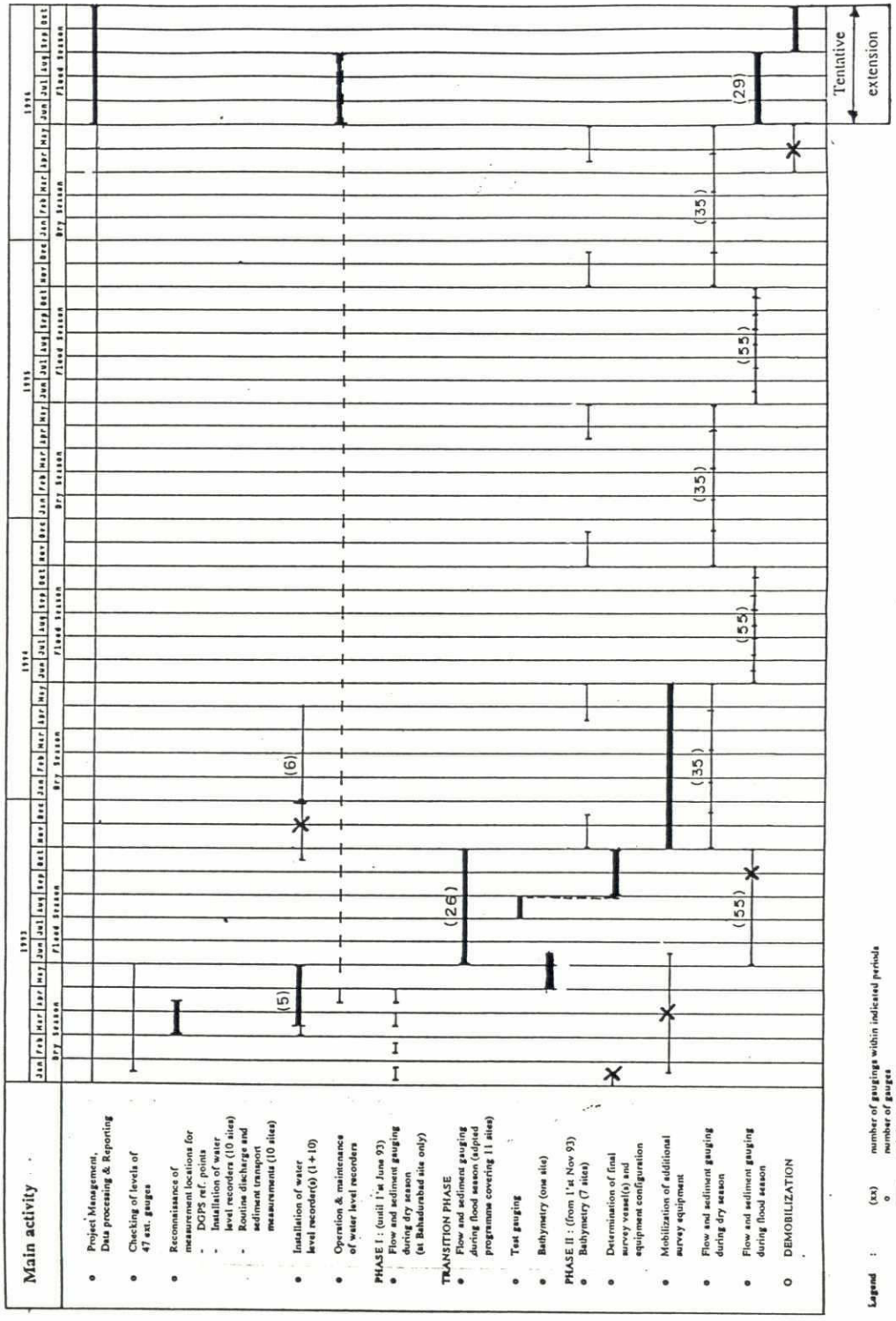


Figure 8.1 Revised survey workplan, February 1993

8.4 Expected results of revision

The impact of the forced delayed mobilization for Phase 2 is used in such a way that the project profits from it as much as possible:

- o The results of the final test gaugings can be used for selecting the appropriate techniques
- o The experience gained at other locations than Bahadurabad can be used for the selection
- o There is time for additional testing (e.g. the bathymetric survey techniques)
- o There is a better coverage of the floods (in case the extension is realised)

Summarizing:

It may be stated that the revised workplan, despite a slower project implementation, serves the project objectives better.

8.5 Detailed workplan

The revisions of the overall survey workplan have been incorporated in the following detailed workplan of the River Survey Project covering the second half of Phase 1 (in accordance with sub-section 4.4.2 of the ToR. For further explanations reference is made to Annexure 9).

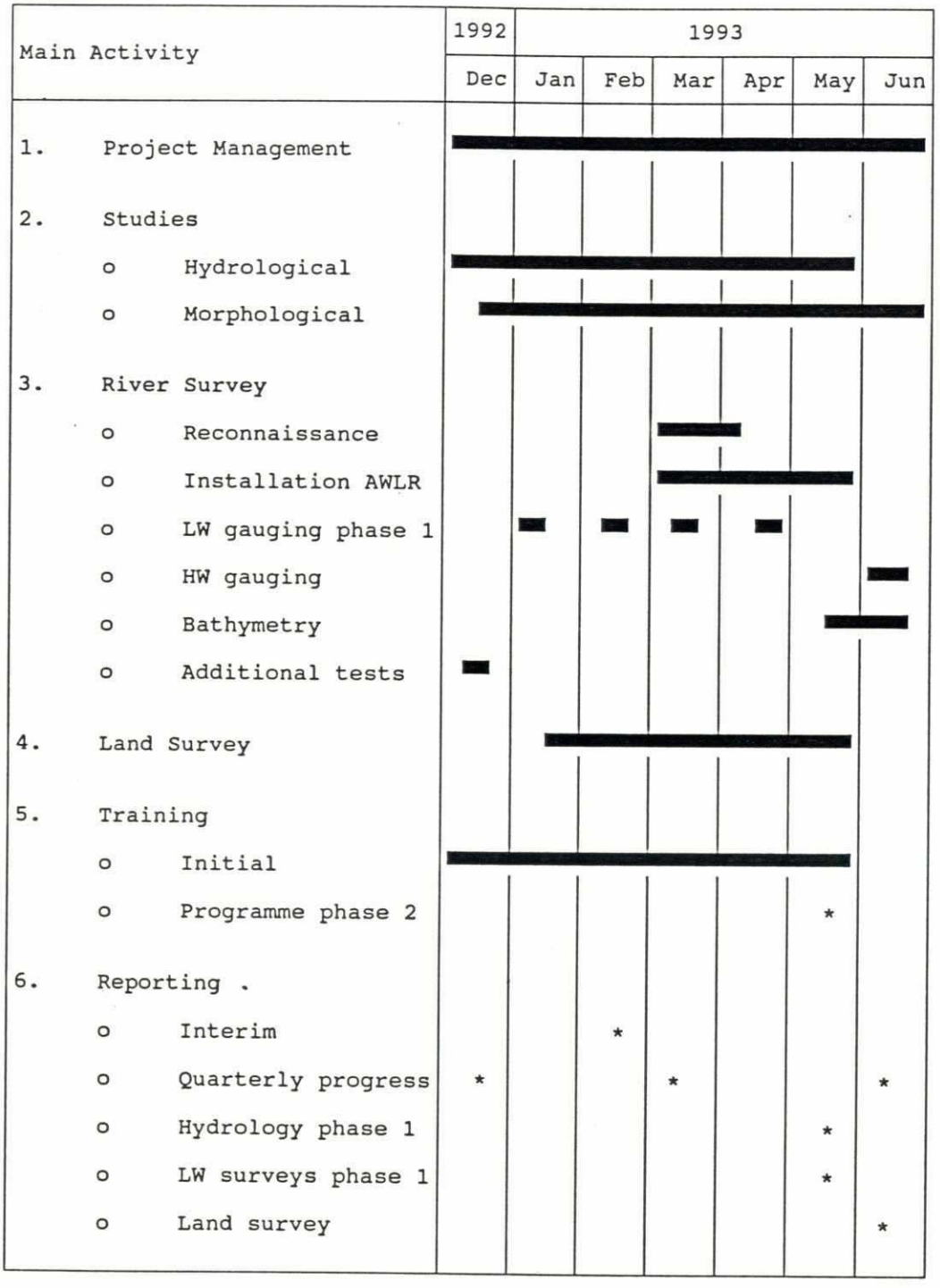


Figure 8.2 Detailed workplan (second half phase 1)

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